THE JOURNAL OF ENGINEERING EDUCATION

VOLUME 38 NUMBER 2

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Published monthly (except during July and August) at Prince and Lemon Sts., Lancaster, Pa., by the American Society for Engineering Education under the Supervision of the Publication Committee: A. B. Bronwell, Chairman, Northwestern University, H. O. Croft, and C. E. MacQuigg. Entered as second class matter, October 17, 1912, at the Post Office at Lancaster, Pa., under the Act of August 12, 1912. Subscription Price, $3.00 per year; Single Copies, 50 cents.

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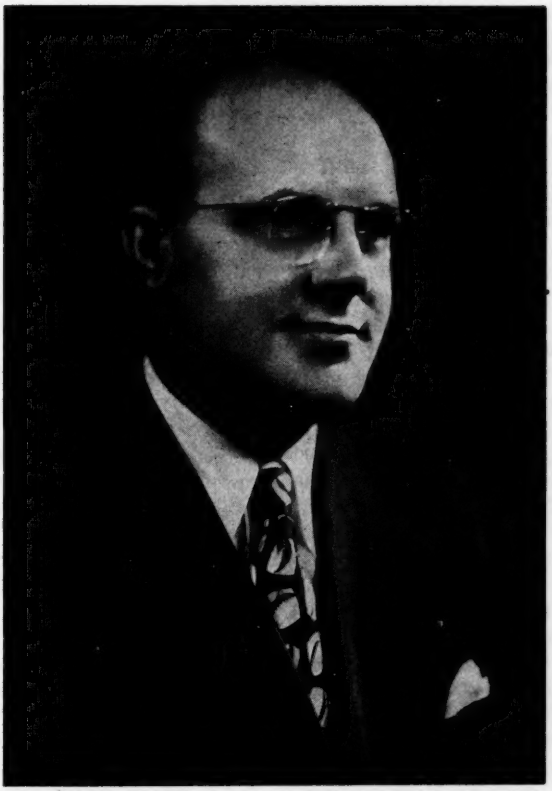
56th Annual Meeting

AUSTIN, TEXAS, June 14–18, 1948

Host

UNIVERSITY OF TEXAS

A. B. Bronwell, Secretary



On October 1, 1947, the office of secretary of the A.S.E.E. was moved to Northwestern University where Professor Arthur Bronwell assumed the post of secretary formerly held by Dr. F. L. Bishop. Professor Bronwell has been on the faculty of Northwestern University since 1937, where he holds the rank of Professor of Electrical Engineering. A product of the Illinois Institute of Technology, he received the B.S. degree in 1933 and M.S. degree in 1936. Additional graduate work in engineering was taken at the University of Michigan and he recently received an M.B.A. degree for work in business administration taken at Northwestern University. His engineering career started in 1930 when he was employed as an operator in substations of the Commonwealth Edison Company, working nights while attending school days. After graduation, he spent two years on a program of re-evaluation of the fixed capital assets of the Commonwealth Edison Company. He was then appointed to the faculty of Northwestern University. During the summer of 1941, Professor Bronwell was employed as a special project engineer by the Bell Telephone Laboratories. At the outbreak of the war, he organized and supervised an Army Signal Corps school at Northwestern University for the training of radio and radar engineers. From 1943 to 1945, he supervised a radar research project at Northwestern University in cooperation with the M.I.T. Radiation Laboratory and Galvin Manufacturing Company. He has served as consultant to Galvin Manufacturing Company, DuMont Company, and others. He is author (with R. E. Beam) of a text on "Theory and Application of Microwaves" and numerous technical papers at Northwestern University he was chairman of a Committee on Faculty Salaries.

Professor Bronwell served as Chairman of the Electrical Engineering Division of the A.S.E.E. and member of the General Council in 1946–47. He also served on an A.S.E.E. committee for the preparation of a teaching manual. He is a member of the American Institute of Electrical Engineers, Institute of Radio Engineers, Sigma Xi, Eta Kappa Nu, and is President of the National Electronics Conference for 1947.

Minutes of the 55th Annual Meeting, A.S.E.E.

The 55th annual meeting of The American Society for Engineering Education was held at the University of Minnesota, June 18-23, 1947. Over 1,300 members and guests were registered. Four general sessions and twenty-six conferences were held. Huber O. Croft, Professor and Head, Department of Mechanical Engineering, The State University of Iowa, President of the Society, presided.

The first general session was opened by Vice President E. B. Norris who introduced Dean S. C. Lind of the University of Minnesota who welcomed the Society to the city and also presented a gavel to the President. President Croft delivered the presidential address, Education for an Atomic Age. T. C. R. Fox, Professor of Chemical Engineering at Cambridge University, England, spoke of the new plan which is being put into operation there. Brig. General John M. Devine told of the University Military Training Experimental Unit at Fort Knox; M. M. Boring presented the report of the Committee on Manpower; and W. N. Jones presented the report of the Committee on Undergraduate Curricula.

The second general session was presided over by J. R. Killian, Jr., President of the Administrative Council. The following program was presented: International Relations of Engineering Education by N. J. Padelford; report of the Committee on Transfer of Students from Emergency Colleges by H. P. Hammond, Chairman; and the report of the Committee on Salary Survey of Engineering Schools by D. C. Jackson, Chairman.

The Thursday evening program was devoted to a meeting with our international visitors. Addresses were delivered by President Croft; Miroslav Jiranek, University of Praha, Czechoslovakia; D. N. Kowshick, Department of Education, India; Rodrigo Flores, University of Chile; A. E. Flynn, University of Nova Scotia; J. S. Thompson and L. G. Straub who had visited foreign countries recently.

The third general session was opened by Vice President C. J. Freund who introduced the Chairman of the Division on Humanistic-Social Studies, E. S. Burdell. The following papers were presented: What Every Engineer Should Know by W. B. Embler; May the Teacher of Literature Help? by A. M. Buchan; American Destiny and Engineering Motivation by A. E. Avey.

The annual dinner was held Friday evening with President Croft presiding. Addresses were delivered by S. C. Lind, Dean of Engineering at the University of Minnesota, and L. M. Gould, President of Carleton College. The Lamme medal was given to Warren K. Lewis, Yale University, and the George Westinghouse Award to B. R. Teare, Carnegie Institute of Technology. The Nominating Committee reported the following for officers. Upon motion they were duly elected:

For President for one year: Charles E. MacQuigg, The Ohio State University.

For Vice President for two years:

B. J. Robertson, University of Minnesota (responsible for general and regional activities).

C. J. Freund, University of Detroit continues in office as Vice President for one year.

For Treasurer for one year: James S. Thompson, McGraw-Hill Book Co.

Previous to this, the Administrative Council had elected S. S. Steinberg, University of Maryland, President for two years. F. M. Dawson, State University of Iowa, continues in office as President of the Research Council for one year.

REPORT OF THE COMMITTEE ON THE SECRETARIAT

By W. E. WICKENDEN, *Chairman*

It is related that one of our lesser colleges invited that august figure, Dean Briggs of Harvard, to give a graduation address. Being gratified by his acceptance, they decided to refurbish the college chapel and revarnish the seats and the pulpit furniture. This was in the days before the drying power of infra red light was fully understood. Unfortunately, hot and muggy weather led to reluctant drying on the part of the varnished furniture, so when the speaker of the graduation exercises was announced, there was a sinister sound of peeling and ripping as his academic costume came loose from the chair, but the dean arose and met the situation with perfect self-possession and aplomb, saying, "Ladies and Gentlemen, it had been my intention to bring you a plain, unvarnished tale."

If the first part of my remarks is to be a plain and unvarnished tale, I shall make it a short tale. It is regrettable that it is an unfinished tale.

We are faced with a crisis due to the retirement from the secretaryship of Dr. Bishop. President Croft, on coming into office, appointed a committee consisting of Dean Dawson, President Doherty, Dean Freund, President Heald, and the speaker as Chairman to give its best consideration of this problem. We began by preparing a job analysis of the secretaryship on the modern tripartite basis of organization and we supplemented this by certain conclusions. First, it would be a great advantage and a substantial economy to the Society to continue its association with one of our centrally located engineering schools. Secondly, that the location should be conveniently accessible by rail, air and motor to as large a proportion of our membership as possible. It should be in an urban and university center, affording adequate accommodations for group meetings and conferences of substantial size. Thirdly, both the administrative load within the Society and the rapidly growing load of liaison relationships with professional, industrial, educational and governmental agencies make it desirable to move as rapidly as possible toward a full time secretarial service.

Next, after reviewing the existing sources of income and probable expenses of our now enlarged organization with the executive committee and taking into account the retirement provisions in view for the secretary and the assistant secretary, it seemed apparent that the present dues of the Society would not suffice to sustain a full time secretary and to provide for the necessary assistance and overhead expense.

The committee felt it advisable to proceed in a provincial manner pend-

ing the possible change in dues and further instruction from the executive committee. It did, however, make a new study of the distribution of our membership and of its geographical center, in order to ascertain the most convenient region for the Society's headquarters. The center of gravity of our membership was found to lie within a triangle bounded by Ann Arbor, Columbus and Cleveland. The committee thereupon decided to canvass the major institutions in the urban centers within this area and in a peripheral zone including Chicago (you Chicagoans may not like that), Cincinnati, and Pittsburgh, to ascertain which institution would be able and willing to provide headquarters for the Society and what individual the executive officers of this institution would recommend as a possibility for an appointment as a secretary, initially on a part time basis if necessary, but with the understanding that the goal in view was a full time engagement.

Of the institutions approached, the University of Michigan, Northwestern, Illinois Institute, and Pittsburgh and Case indicated their willingness to provide secretarial headquarters and suggested in all eight possible candidates for appointment.

In the meantime, our executive committee had inaugurated a canvass of the membership on the question of an increase of dues and pending these returns has been unable to give our committee instruction and a budget having to do with secretarial salary and expense. While it might have been possible to approach some of the candidates suggested on a purely elastic basis of part time service subject to later adjustment, the strong desire that had been expressed by certain of the officers of the society and members of the committee seemed to make it unwise to approach any candidate until our special committee and the executive committee had been able to confer together on all aspects of the situation and this conference was arranged for Wednesday morning of this convention week.

Meeting together at this time, the two committees agreed first to maintain the secretary's office, if possible, in connection with one of the institutions within the region previously canvassed; secondly, to appoint a secretary on an initial basis of approximately two-thirds time service, that is, leaving open the possibility of his carrying half load academic engagement, at a salary making the position attractive to a young man of excellent ability in the intermediate academic or administrative ranks of our colleges; and third, to select if possible an appointee who has had an active record of participation in the Society's affairs, and who can be counted upon to continue and upbuild the record of widely decentralized activity, rather than to build up a highly centralized plan of operations. Finally, in order to assure immediate steps to carry out these measures, the executive committee agreed to relieve the present chairman of the special committee of that responsibility, as it will not be possible for me to give active service in the early part of the summer and I am happy to announce that the chairmanship of the committee has passed into the highly capable hands of our good friend, President Heald of the Illinois Institute of Technology. Active measures will be taken as quickly as possible to carry out the general policy herein indicated. That part is the plain, unvarnished tale.

The rest, I trust, has a little more romance and color. All of you have heard the oft-repeated classic that every great institution is but the lengthened shadow of a man, and to that many of us can testify from long association with this Society. I recall being stopped one time upon the street corner by the Dean and Nestor of all of us, old Professor C. Frank Allen, one of the founders of the Society, I believe its first secretary, who in my early teaching days told me he had observed that the young men in engineering education who were likely to go far were those who took an active part and interest in this great organization. After a long period of association with the Society from the most junior of its ranks to now one of the older guard, I can testify through intimate association to the aptness of this classic expression as it relates to our retiring secretary. The shadow of a man—unobtrusive, but inseparable from every interest of the Society. Silent most of the time, but knowing everything, and never getting between any man or this great institution and the sun.

Now I don't know with what illusions Fred Bishop may have begun his service as Secretary 33 years ago, whether hopes of increased income or fame may have led him on, but I am certain of one thing that he has continued through all these years at a constantly increasing sacrifice of time and comfort and I suspect of financial income as well. It is just that spirit of self-dedication that makes the annals of education glorious and has created such an irresistible appeal to men of high spirit, and on this occasion of his retirement I should like to move that this Society spread on its minutes the following testimonial to Frederic Lendall Bishop:

FREDERIC LENDALL BISHOP

The American Society for Engineering Education, on the occasion of your retirement from the office of Secretary after thirty-three years of devoted service, desires to express to you its deep gratitude and enduring affection.

Under Your Wise but Self-Effacing Guidance, the Society has attained to a commanding influence in the realms of higher education and professional endeavor. As a common forum for the problems of instruction, administration and research, it has rendered a notable service to teachers and colleges alike. It has united those who guide, teach and inspire students of engineering in a fraternal bond rarely equalled and never surpassed.

Ceaseless Fidelity, unvarying loyalty to worthy goals and sound standards, a progressive spirit, concern for the welfare of students, devotion to freedom for teacher and school, and resourcefulness in achieving great ends with modest means . . . these have been the personal hall-marks of your administration.

You Have Become a Tradition among us, worthy of the high place of honor and affection in which we shall always hold you.

On behalf of the Society

Hubert O. Croft
President

June 20, 1947

On behalf of the Society, and to be signed by its President, I move, Mr. President, that we engross this resolution of testimonial upon our minutes and present it to our retiring Secretary.

SECRETARY BISHOP: Mr. President, this is kind of a bad position to be in. I should have studied more sociology and very much less science—I can see that now.

Of course, it has been a great pleasure to be Secretary of this organization. The friendships have been remarkable. The Secretary's office, you know, operates through Miss McKenry. Don't you get any idea that I do the work, or even create the ideas. At the time I took over the Secretary's work, among other things, the Society for the first time appropriated $40 a month for clerical and editorial assistance.

Well, it is going to be a tough job to find a new Secretary that will do as much as the present group does—I know that. Of course, while the committee is looking around, Miss McKenry will carry on. Right now I wish that would extend over a long time. I thank you one and all. (Dr. Bishop was presented with a silver tea service, various pieces of which were prsented by Webster Jones, Dean Earle, Dean Hammond, Dean Ferguson, Dean Potter, and Dr. Jackson.)

The fourth general session was presided over by F. M. Dawson, President of the Research Council. The following program was presented: Synopsis of the Annual Report of the President, F. M. Dawson; report of the Committee on Federal Research Agencies by Thorndike Saville; report of the Committee on Legislation by Thorndike Saville; report on Senate Bill 493 by E. B. Norris; Physiological Problems Encountered in Engineering by Philip Drinker; Research Problems and Opportunities in the Field of Jet Propulsion by S. F. Duncan; Research in Turbulent Flow by J. S. McNown.

The following resolution was presented and accepted by a rising vote:

We, the members and guests of The American Society for Engineering Education, wish to thank our host, the University of Minnesota, for the leadership, cooperation, and friendliness that have made this 55th annual meeting an outstanding success. We are especially grateful to President J. L. Morrill; to Dean S. C. Lind and his Faculty in the Institute of Technology; to the genial, patient, and helpful Chairman of the General Local Committee, Professor B. J. Robertson, and to the Chairmen and members of his many committees.

We are grateful also to the Convention Bureau of the Chamber of Commerce for assisting the local committee; to the Minnesota Hotel Association for arranging reservations; and to the Nicollet Hotel for providing us space for headquarters and meetings.

For the gracious hospitality provided for the ladies attending the meeting, we express our appreciation to Mrs. H. E. Hartig and the members of her committee.

Since we think that our various programs have been particularly interesting and stimulating, we wish to thank our speakers, our officers, and all the committees representing the divisions and special conferences.

Inasmuch as this is the last meeting under the guidance of our able secre-

tary, Dr. F. L. Bishop, we wish to recognize here his long and faithful service and his many contributions to engineering education and to the outstanding growth and prestige of this Society.

WE RESOLVE, THEREFORE: That this expression of our gratitude and appreciation be recorded in the minutes of the meeting and be duly conveyed to all those herein mentioned.

(signed) L. O. STEWART,
Iowa State College,
S. S. STEINBERG,
University of Maryland,
W. T. ALEXANDER,
Northeastern University,
W.O. BIRK,
University of Colorado, *Chairman.*

The meeting adjourned sine die to meet at the University of Texas, Austin, Texas, June 14–18, 1948.

Minutes of Couucil Meeting, June 18, 1947

Present: H. O. Croft, H. W. Barlow, W. O. Birk, F. L. Bishop, A. B. Bronwell, E. S. Burdell, L. E. Conrad, H. A. Dangel, C. L. Dawes, F. M. Dawson, H. L. Dodge, W. R. Dumble, C. D. Fawcett, C. J. Freund, T. C. Hanson, E. D. Howe, J. R. Killian, R. C. Kinter, J. H. Lampe, W. M. Lansford, L. S. Letellier, S. C. Lind, H. J. McIntyre, D. F. Miner, G. Murphy, E. B. Norris, O. N. Olson, G. K. Palsgrove, B. J. Robertson, H. S. Rogers, S. S. Steinberg, J. S. Thompson, A. W. Turner, H. W. Wood, W. R. Woolrich, J. H. Zant.

The report of the auditor was read and accepted as the report of the Treasurer. It was ordered printed.

President Croft presented the following report:

A retiring president's address is easy to deliver but difficult to compose. For of necessity it must be a hodgepodge made up of an expression of thanks to those who have helped, an annual statement to the stockholders, an explanation to those few who have disagreed with policies adopted, a brief sermon looking toward the future, and a sigh of relief for the completion of a job.

This is the end of the first year of operation of the American Socity for Engineering Education under the new constitution adopted by you a year ago at St. Louis. During the transition I doubt if many of you have noted any change in that comfortable feeling you experienced from your membership in the Society for the Promotion of Engineering Education. In fact there has been little change. You, the General Council, are now more representative of the Society as a whole, and the engineering college administrators and the engineering college research directors have the autonomy necessary to act quickly when the time element is essential.

For example, the Engineering College Research Council has been more than influential in having engineering research finally included in the Research Foundation Bill now pending before Congress. Engineering research had been expressly omitted in the original bill submitted for hearings. I wish here to express my congratulations to E.C.R.C. for this real accomplishment. Again I wish to express my sincere thanks to Dean F. M. Dawson, President of E.C.R.C., and his executive committee for the sympathetic and complete cooperation they have given during the past year.

Likewise, the Engineering College Administrative Council under the leadership of President Killian has been helpful in its advice and generous in its cooperation. It was at the suggestion of E.C.A.C. that the Report on Academic Tenure was sent, after the approval of Council, to all presidents of engineering institutions. It should also be noted that their committee on military training is studying very carefully the proposed legislative program for compulsory military training.

Vice Presidents Freund and Norris have worked hard and long on much of the detail work that has been carried on for the proper functioning of the Society. We owe them much and I wish to offer them the thanks of the Society.

We are likewise particularly grateful to those of you who worked on the Membership Committee. You have made an all time record in new memberships. You have enrolled 887 new members this year which makes a total membership of 4,592 at this time, plus 165 institutional members, bringing the total to 4,757. This is the largest membership the Society has ever had. Let all of us welcome these new members and help them to understand why our group is unique.

The only matter that has been undertaken this year which seemed to be in the least controversial was the ballot on the increase in membership dues. The real controversy was not as to whether an increase in dues was justified, but rather what form the increase should take, whether it should be a blanket increase for all or a graduated increase according to rank. This matter was presented first to the executive committee and then to Council. The ballot submitted to you was the one approved by most of the members of Council. I am delighted to report that 1,989 ballots had been received up to midnight on June 14th. Of these 1,492 or 74 per cent, were in the affirmative; 487, or 25 per cent, were negative; and 10, or 1 per cent, were disqualified either because they were not marked, because they were not signed, or because they could not be interpreted. Since the constitution provides that the majority of the ballots received shall determine the issue, all of us will be billed at the new rate for annual dues next July 1st—grades under associate professor, $5.50; associate professor, $6.00; all others, $7.00.

I wish to express the gratitude of the whole Society for the outstanding work of our 36 committees and their chairmen. You can judge the excellence of the work they have done in the fifty or more sessions they are producing here for our benefit.

One of the most satisfying experiences of my life has been that as your representative on the First National Advisory Committee of UNESCO, the United Nations Educational, Scientific and Cultural Organization. This group, authorized by Congress, is one of many similar bodies working in most of the member Nations of the United Nations to promote peace, good will and mutual understanding between the peoples of the world. What UNESCO lacks in budget is compensated for at least partially by the sincere enthusiasm of the members. All of us hope, I am sure, that UNESCO will succeed in its fundamental objectives.

It was through the inspiration of UNESCO that I took the liberty of asking the State Department to send an invitation through each of their consular offices to each country with whom we maintain diplomatic relations. This invitation to attend this meeting here in Minneapolis was extended to a prominent engineering educator in each country. The first approach was made to the State Department in December but for various reasons the invitations were not sent to the consular offices abroad until April. Dr. Dowdell of the University of Minnesota was asked to be the liaison official here for all foreign guests. He advises me this morning

that 20 guests from foreign shores are among us this morning. It seems to me that invitations to our colleagues abroad and one session of the annual meeting during which our guests may discuss their problems with us should be an annual tradition. This is one way we may really contribute to international appreciation and understanding.

As many of you know, F. L. Bishop, a member since 1907 and after serving this Society faithfully and well as Secretary for 33 years, retires in July from his academic activities at the University of Pittsburgh and likewise from his leadership of this Society. It is difficult for me to express those thoughts of appreciation which are in the hearts of all of the older men in the Society. The history of this society has been made in no small part by the imagination, by the planning, and by the devotion of Dr. Bishop. Under Dr. Bishop the membership has grown from about 1,300 to 4,800. Many Presidents have served under him and all of them have finished that service with a deep appreciation of his insight into the strange actions of man, his keen sense of humor, his inherent sense of justice, and his absolute reliability. He has been an inspiration to me as he has to all of his friends in the Society. The Society will be fortunate to say the least if it can obtain a successor who even partially will fill his shoes. We wish Dr. Bishop a happy and fruitful future for the free days that are now his.

Miss McKenry, who has served the Society for the same length of time as Dr. Bishop, has been priceless in the performance of her duties. Without her the President would have been lost in a fog during the past year. To her I offer my sincere gratitude and likewise a personal apology for the many sins I have committed.

I have tried to analyze for my own satisfaction what is inherent in this Society that draws us together once a year to dicsuss almost the same material year after year and I have come to the conclusion that it is the aggregation of great men who gather at this meeting, men who are following in the footsteps of Baker, Allen, Jackson, Talbot, Raymond, Marston, Ketchum, Cooley and Sackett, to mention but a few. Men comparable to these are here now if you but look about you, and fail not to search particularly in the younger group of men if you wish inspiration and stimulation. It must be the deep personal friendships that are ripened over the years that really bring us back to this annual meeting and only incidentally does the public discussion of our common problems really justify our presence. I suspect that there are fewer cliques, regional, functional, or political, in this society than most, and it is your responsibility to maintain this characteristic of our unique society.

The Secretary's report was accepted and ordered printed.

The report of Vice President E. B. Norris on Sections was accepted and recommendations therein left for action by the next Vice President (B. J. Robertson).

Life membership was conferred upon W. C. Ebaugh, W. H. Kenerson, R. A. Porter, R. E. Root.

Sub-committee of the Comittee on Relations with Industry:

Committee on Ethics of Personnel Interviews and Practice: M. M. Boring, C. E. MacQuigg, J. C. McKeon, A. A. Potter. The report is to be sent

to the new President and he should appoint a committee to study further the present code of ethics.

W. E. Wickenden reported on secretariat. (See report made at annual dinner.)

H. S. Rogers appointed as representative on Engineers' Council for Professional Development.

W. E. Wickenden appointed as representative on American Council on Education.

W. R. Woolrich invited the Society to meet at the University of Texas, Austin, Texas, in 1948. This invitation was accepted and Monday noon June 14 to Friday noon June 18 were the dates set.

A revision of the present Constitution and By-Laws was referred to the Committee on Constitution.

One hundred and eleven new members were elected, making a total of 887 new members for 1946–47, the largest number in the history of the Society. We now have 4,592 individual and 165 institional members, a total of 4,757 members.

Report of the Committee on Manpower*

By M. M. BORING, *Chairman,*
General Electric Company

I must report to you that this can only be considered as an interim report. There are a number of factors involving the manpower problem that have come up making it necessary for us to continue the study of the problem in order to give you a complete report which, we hope, will be accurate.

I am not going to bore you with a stream of figures, but will give you a few pertinent facts at this time. We could, I suppose, sum up the entire report by saying there is going to be more, soon.

Last summer in July, at the time the so-called Compton Report was made by Karl Compton, we had a great deal of guess work in connection with the enrollment and also in my opinion some guess work in connection with the demand side of this important problem.

After enrollment was completed in September, 1946, of last year's group, Mr. Armsby, in Washington, a member of our Committee, made a complete and very accurate study of the actual enrollment of the technical students in the country. I will give you the total results of that study.

His study indicated 92,600 freshmen, 57,500 sophomores, 33,800 juniors, 23,400 seniors and 800 fifth year men in the engineering colleges. We find 14,900 students unclassified, who clearly are candidates for degrees in this period of time. Assuming the same rate of admission, we used last year's rate—this factor must be studied. Some of the schools are still in session and we do not have an accurate figure of admission under the present situation so we are going back to last year's assumption which is the only basis on which we can, at the moment, make our studies—the study would indicate the senior class of 1947 was 23,000, the class of 1948 will graduate 31,000, the class of 1949 should graduate 36,000 and in the class of 1950 there will be 58,000 students.

Another important study, which was missed completely in last year's report, was the number of young men in the other colleges who anticipate transferring. We do not refer to those boys in the Government temporary pre-engineering schools, but to those in colleges such as arts and other types of institutions. Mr. Armsby again took on the job of surveying that group. He contacted over 1,100 such institutions and has replies from roughly 900, which indicates we have in these schools, who expect to transfer this coming year or in the next two years, an additional 77,000 boys, of whom we estimate 55,000 will enter freshman classes in engineering and 22,000 will enter other classes—sophomore, junior or senior as the case may be.

* Presented at the 55th Annual Meeting, A.S.E.E., Minneapolis, June 18–21, 1947.

We believe that we are faced in 1951 with an even higher admission than we would normally use, and there will be another group of 54,000 in that particular class who will be thrown on the market.

I would like to say, and I am sure I speak for every member of the Committee, we do not think this is quite as serious a situation as was first believed. It means that it is high time we start preaching to our young people in college that this training is without question the best preparation for life. Whether they get into an engineering job is, in reality, of secondary importance. If we can plant that in the minds of our young people, over-production in this country will not be very serious. However, if we do turn out a very large number of students in the next few years unable to find jobs in the field for which they are prepared, we are facing rather serious difficulties as far as the country is concerned.

On the supply side of the picture, therefore, we feel we have a fairly accurate size-up of the problem. The figures I have just given you on the demand side of the picture indicate there are three basic areas that we feel must be carefully surveyed. Just a word on our attempt and procedure.

In the first place, we must know how many people the colleges need to employ as instructors and professors in order to continue their educational processes. We have contacted all of the deans of the engineering colleges in the country. We have received replies from a high enough percentage to believe that we have an accurate idea of the college needs. In 1947–1948 they will be asking for 1,745 people, of which 1,050 are new and 695 experienced; in 1948–1949 for 1,565, 923 new and 642 experienced; in 1949–1950 for 1,360, 630 new and 730 experienced; and in 1950–1951 for 1,160, 510 new and 650 experienced. There is an indication that specialization in schools means a continual downward trend in the demand for additional people in education. We can assume from information received that if we can man the colleges to take care of the present load, future additions to faculty will be unnecessary.

We are having real difficulty in making a good survey of governmental needs. At the present moment we know certain branches of the government have already had very serious budget cuts from the new Congress. This is having a serious effect on our manpower survey. For example, we know the Bureau of Reclamation is laying off thousands of people at the present time. REA is releasing 1,500 people and many other Bureaus are worrying and wondering what their situation will be. It is utterly impossible at this time to get good accurate figures. The best information that Dr. Trytten can bring us from his contacts in Washington is roughly that an additional 3,000 a year will be needed from the colleges by the various governmental bureaus. State organizations are in exactly the same boat and in our survey (on which I will touch in a moment) as to the needs for civil engineers, we do not believe that our figures are accurate. We know that a large percentage of the civil engineers go into federal, state and local governments. Our manpower figures for this group are unobtainable. For these reasons we are using the total figure of 3,000 a year for all forms of government.

On the industrial side of the picture,

last year the report was made from a compilation of information from 125 companies. I have mentioned to some of my friends around the circuit that I would guess that there are 3,600 companies visiting the colleges to recruit engineering people. We have gone to the schools and asked them to give us the names of every industrial organization that has contacted them, whether an engineering concern, a bank, or what not. There are all types requiring engineering people and we had, at the time I left, collected the names of 4,247 organizations involved in this particular problem this last year. We have sent to those organizations a simple questionnaire asking for their manpower requirements, and that information is pouring in at a great rate. We have collected information from 605 organizations, and by interpolation have arrived at the following figures:

Industry should demand from the class of 1947, 23,300 people directly from college. They need an additional 9,900 or a total of 33,200. In 1948 they ask for 22,100 new and 8,600 experienced, or a total of 30,700. In 1949 a total of 28,200; in 1950 a total of 26,900; in 1951 a total of 26,100; and in 1952 a total of 25,800. There is a continually dropping curve throughout this entire period.

Another problem facing the schools is that if an organization employs an experienced man, he will have to be replaced by a younger man from college some place down the line. In other words, that figure given as the total demand of industry will be in a large part the demand from the schools themselves.

Another very interesting figure is the total of the results and I will go over that quickly. In 1947, including the demand of industry and government, the total will be 36,200 with a supply of 23,000 or a shortage of 13,200. In 1948 we show a total demand of 35,545 with a supply of 31,000, which is still a shortage of 4,545 boys. In 1949 there will be a total demand of 32,765 and a supply of 36,000 which we believe will probably be about "even-Steven" or on the line, if you will, and in 1950, when the very large freshman class strikes us, the demand will be 31,230 with a supply of 58,000, which indicates a surplus of 26,770 people. Going on to 1951 we will have a surplus of 22,740, which drops a little from the great peak unless our attrition is very, very high, unless we work harder to eliminate the poor ones.

These boys ought to be warned that it is not necessarily a very serious situation if they do not find jobs in the companies that employ engineers. They should realize there will be an oversupply in 1950, but that an engineering education is basically as good an education for life as any they can take.

Quickly breaking down I will give you the various types of engineers in which I think you would be interested. The aeronautical group is already oversupplied according to the figures. There is an oversupply which will increase for the next four years up to a maximum of 1,650. It is a relatively small group.

There is still a heavy demand for chemical people and this will continue throughout the period coming out with a slight surplus which will mean, if anything, a balance or still a small shortage in 1950.

For civil engineers we do not have figures that are of any value. We do not have a sufficient picture of the

demand side to make the figure accurate. We believe generally that the civil engineer balance will not be reached before 1951. They will still be needed in large numbers with the expectation of many government projects.

The electrical engineers are the serious problem. It is increasingly clear that we are going to have a considerable oversupply in 1949 and an exceedingly high oversupply by 1950. I feel we should watch that very carefully as there are large numbers being attracted to the electrical phase of engineering due to the various contacts the G.I. had in the war with different phases of electrical engineering, such as radar, etc.

For mechanical engineers there is a tremendous demand and it will continue. Our figures show a slight oversupply in 1950, but it is not at all serious and I feel that we can use good mechanical engineers as fast as they can be produced.

Mining and metallurgy show a slight oversupply which we feel is wrong. We think there are many more places for engineers of this kind.

As for other groups, from the best information we can obtain by putting all other kinds of engineering into a lump, as we did in last year's report, we have found there will be a heavy oversupply. It would be wise to encourage some of these boys to switch to mining and metallurgy or mechanical engineering.

Very briefly, gentlemen, that is an interim report by your Manpower Committee. We are going to have to ask for more and more help, and as Dean Harry Curtis at the University of Missouri wrote me, "Your confounded questionnaire came in," and I suppose I will have more statements of that kind pretty soon. This is an important subject and your Committee intends to keep on working with it. We hope that well before enrollment begins we will be able to supply you with accurate substantial figures on which you can base your judgment.

A Proposed Engineering Aptitude Test for High School Students*

By K. W. VAUGHN

Director, The Measurement and Guidance Project in Engineering Education

Introduction

The Measurement and Guidance Project in Engineering Education is engaged in systematic development and evaluation of tests and examinations designed to reveal aptitude and achievement in various stages of the engineering curriculum. In this examination structure, provision has been made for the construction and validation of an engineering aptitude test suitable for high school sophomore students. The purpose of this paper is to outline general principles which will guide the development of this test and to describe briefly the major abilities and achievements which appear to be necessary components of engineering aptitude.

I. The Need

An aptitude test suitable for discovering possible engineering talent in the high school may properly be classed as a guidance test. It is generally recognized that a guidance test should be administered at a time in the student's development when he needs to have information concerning his potentialities and the areas in which his energies and intellectual development may properly be directed. Furthermore, such tests should be available at a time when there remains an opportunity for the student to complete the necessary stages of development before specialized college study is undertaken. That is, the student should be provided with dependable measures of his capacity for the further study of scientific subjects as early as possible if he is to prepare himself for the study of engineering. It is not enough to ascertain the student's interest or his achievement in formal courses to serve as a basis for such guidance. Carefully-constructed tests should be used to provide dependable and objective estimates of individual possibilities and potentialities.

It is generally recognized by educators, guidance officers, and psychologists that the high school student's interest and study pattern can be modified by intelligent advice which becomes more effective when supported by objective evidence provided by examination or test scores. Admissions officers and deans of engineering generally prescribe a series of subjects which students are required to have completed before the engineering curriculum can be undertaken. While such prerequisites are generally well publicized from the point of view of the college of engineering, this information sometimes does not get into

* Presented at the 55th Annual Meeting, A.S.E.E., Minneapolis, June 18–21, 1947.

the hands of students soon enough to permit the student to choose a course of study which will lead him into the study of engineering. A systematic guidance program in secondary schools, which provides adequate testing instruments and occupational information, and places this information in the hands of students at appropriate times, can do much to guide prospective science and engineering students into proper advanced courses in the last two years of secondary school study.

From the point of view of the engineering curriculum, the sophomore year in high school is an appropriate point to begin exploring the potentialities of individuals with respect to the possible study of engineering. Generally, the student has completed two years of the basic sciences—general science and biology. In many high schools, students will have completed elementary algebra and plane geometry. This pattern, of course, varies considerably in various parts of the United States and among high schools with divergent philosophies concerning the place of formal mathematics in the secondary school curriculum. In general, however, the student will have pursued the first science courses and the elementary mathematics courses which are fundamental to the subsequent study of engineering. By having taken such subjects, most students will have formed a very definite opinion as to their interest in further study of these fields in high school and will possibly have projected their interests forward into the college.

While the elective system within the last two years of high school is relatively restricted as compared with college curricula, there is in most cases an opportunity for the student to elect further courses in science and mathematics during the last two years of high school. Thus, the end-of-year high school sophomore student who is soon to register for his junior courses should be provided with some basis for evaluating himself in relation to his educational study plan. In this connection, he can be advised of the information provided by aptitude tests, interest tests, and other objective instruments which can assist him and his counselors in making decisions affecting his further study.

. It appears, therefore, that there is a need for an engineering aptitude test at the high school sophomore level and that such an instrument will be of considerable value in the guidance of high school students.

II. General Principles of Development

In developing the engineering aptitude test, the Project staff will be guided by several practical and technical principles. Some of these principles are general in character and others serve as standards for evaluating the test materials as they evolve through successive stages of development. Certain of the most important of these principles will be discussed briefly.

1. *The purpose of the engineering aptitude test will be clearly defined.*

The purpose of the proposed engineering aptitude test is to provide measures which are predictive of the student's success in advanced mathematics and science courses in the last two years of high school study. It is assumed, and there is much evidence to support this assumption, that abilities developed in these subjects are most predictive of initial success in the first

stages of the engineering curriculum. This fact has been borne out repeatedly in researches of the effectiveness of the Pre-Engineering Inventory.

Secondly, the performance on the engineering aptitude test must be related to success on the Pre-Engineering Inventory. Specifically, the purpose of the engineering aptitude test is two-fold in character: (1) performance on the test must predict, with good precision, the student's later success in scientific subjects in the high school; and (2) individual performance on the test must also be highly related to performance on certain sections of the Pre-Engineering Inventory.

2. *The engineering aptitude test must be valid for its purposes.*

One essential aspect of test validity is that the results derived from an examination are dependable for the operating purpose of the examination. In general terms, an individual who receives a high score on the engineering aptitude test must systematically achieve a better understanding and competence in subsequent courses in high school mathematics and science than an individual who receives a low score on the test.

If the aptitude test were perfectly valid, it would also be perfectly reliable, that is, the individual who received the highest score on the engineering test in any group of sophomores would consistently be the best student in advanced courses in the fields of mathematics and high school science. Similarly, all other individuals would retain their relative position in achievement as forecasted by the measures of aptitude. This, of course, is too much to expect of any examination. However, a definite effort must be made to increase the precision of the aptitude test so that guidance officers in high schools can predict with good precision the individuals who are likely to experience difficulty in the advanced study of mathematics or science and to identify those individuals who would profit by continued study and possible preparation for engineering study at the college level. Validity, then, will be our essential problem in the development of this examination.

3. *Each sub-test must be as reliable as possible.*

In test development, reliability is a correlate of validity. In the case of aptitude tests, validity may depend very largely upon the factors or components of success which are measured. Reliability deals with how effectively such factors are measured. To illustrate, scholastic ability does not account for nearly all of the failures which occur in the secondary school. It would be possible to enumerate a long list of other considerations which must be taken into account when an individual does not achieve satisfactory marks in science, mathematics, social studies, or other secondary school subjects. However, if we are to ascertain what role scholastic ability does play, it is necessary to measure such abilities as precisely as possible.

To illustrate further, is is certain that the engineering aptitude test must include a section dealing with mathematics. Our first problem is to measure as dependably as possible the student's general ability in this area. We have criteria by means of which it is possible to tell how dependably we are measuring mathematical ability. When we consider validity, however, we are concerned with the problem of

how much mathematical ability contributes to the success of individuals who continue the study of this and related subjects.

4. *The results on the aptitude test must be differential in character.*

Guidance tests where more than one ability is measured should provide for differential scores. Except in unusual instances, it is generally desirable to provide separate scores for each ability or subject area included in a series of test. The engineering aptitude test will provide at least four measures, and possibly five, depending upon the scope of the series. The report to students and counselors will be in the characteristic profile form in which relative performance in each of the abilities can be shown graphically. In addition to scores on the separate tests in the series, a composite score will be provided.

5. *The test will be efficient in scope and in administration time.*

While short tests are most easily administered, it is not always possible to devise a short test which is both reliable and valid. Thus, we shall be first guided by validity; secondly, by reliability; and thirdly, by efficiency of administration time. It is certain that the test will be reduced in length as much as possible in order to encourage its use and without impairing its value from the point of view of guidance.

6. *The tests will be difficult.*

One of the most significant findings of the early experimental work was concerned with the difficulty of available test materials. Tests of ability in mathematics and science which are properly adjusted in difficulty to the abilities of all students enrolled in the high school, or college freshmen generally, are not sufficiently difficult for prospective engineering students. The engineering aptitude test will necessarily be a difficult test. It will distribute effectively the scores of the upper one-half of groups in mathematics and science courses; below-average students will find many questions which cannot be answered or problems which cannot be solved correctly. Only in providing a difficult test at this level will the differentiation necessary for proper guidance be provided. Naturally, the test materials will not be so difficult that capable students will be unduly discouraged.

III. Principles of Construction

It is not necessary to discuss here the specific principles of test construction and development which will be utilized in the writing and refinement of the test questions and the sub-tests in the series. It may be of interest, however, to present here a brief discussion of the major abilities to be sampled by the test. Data which support the plan for constructing the tests are reserved for a succeeding section.

It is expected that three major abilities will be sampled by the aptitude test. A fourth ability remains in question, and probably will be provided in a separate test which will be optional on the part of counselors and teachers. The three abilities which will definitely be sampled by the test are: (1) ability to comprehend and interpret scientific materials, including scientific vocabulary; (2) general mathematical ability; and (3) ability to comprehend mechanical principles. The optional test is spatial visualizing ability. In the Pre-Engineering Inventory, the tests which measure the ability to com-

prehend the meaning of important words in the vocabulary of high school science and mathematics and the ability to comprehend and interpret reading materials in scientific fields have consistently proved that their results provide a good prediction of a student's success in engineering subjects. In general, the materials included in the test which combines vocabulary and reading comprehension of scientific materials will be concerned with general science subjects. Some emphasis will be placed on biology, although biological concepts will not be sampled nearly to the same extent as will the various topics included in general science courses.

The test of general mathematical ability will measure the student's ability to solve problems ranging in difficulty from arithmetic through plane geometry, to interpret graphs and tables, and to apply mathematical thinking to the solution of new problem types which the student has not previously encountered in his formal study, but for which he presumably will have developed the ability to proceed in an orderly manner. This test will measure both achievement and aptitude, and may properly be called a general ability test.

Although of limited use for perdicting general success in the study of engineering, the ability to comprehend and apply physical principles and to solve problems involving direction of motion, and mechanical principles at an elementary level is probably a very necessary aptitude for a study of physics. It is believed also that this test will be an indicator of interest and therefore be of considerable value for the student's readiness for the study of physics or chemistry.

A spatial visualization test may increase the length of the series beyond the point of efficiency. Unquestionably the ability to visualize form and detail from plane figures is an important aptitude for a limited aspect of engineering study. It may be desirable to include this test in the aptitude battery, or it may prove more feasible to provide a separate test of this ability. The decision in this matter cannot, of course, be made immediately.

Experimentation will be conducted with each of the four tests already described.

IV. Pertinent Data

The decisions concerning the content and emphasis of the engineering aptitude test are based largely on experimentation with engineering freshmen. These experiments were conducted in connection with the development and validation of the Pre-Engineering Inventory. It will be of interest to present here data concerning the predictive value of the seven tests included in the Pre-Engineering Inventory.

Lacking uniform criteria among the colleges of engineering participating in the Engineering Project, our initial researches on the predictive value of the Pre-Engineering Inventory must necessarily be based upon the relationship of test scores to grade-point averages as reported by the college of engineering. As is generally recognized, this procedure is not entirely adequate. Grade-point average as a criterion has serious limitations and the resultant correlation of test scores with this criterion does not ordinarily produce correlation coefficients in excess of .60. Multiple correlation procedures in which each of the several tests in a battery is weighted in ac-

cordance with its relative contribution in the matrix are usually necessary before such a predictive value is achieved.

When these factors are taken into account, a battery of tests which produces such a correlation of .50 to .60 is considered adequate for purposes of guidance and, in many cases, selection. Indeed, most colleges and universities utilize test batteries whose validity coefficients (as based on the grade-point criterion) are very much less than .50. When test batteries whose composite scores correlate with grade-point average during the first semester or first year of study of the order of .60 or higher, the battery is usually classed as a superior instrument. Individual tests which correlate with this criterion or course grades in excess of .50 can be considered as most useful for purposes of predicting success in the subject or area.

Let us consider now the correlation of scores on the several tests in the Pre-Engineering Inventory with grade-point average during the first semester of study in ten colleges of engineering. Only summary results are presented for this group of colleges which administered the Pre-Engineering Inventory in the fall of 1944 and, in four cases, in the fall of 1945. The colleges represented in the data presented below are:

The California Institute of Technology
The University of California at Los Angeles
The Carnegie Institute of Technology
Georgia Institute of Technology
Massachusetts Institute of Technology
The University of Michigan
Newark College of Engineering
North Carolina State College of Agriculture and Engineering
Oklahoma Agricultural and Mechanical College
The University of Texas

Each of these colleges of engineering administered all seven tests included in the Pre-Engineering Inventory with the exception of one college which did not give *Test VII—Understanding of Modern Society.* The composite score on the battery was an experimental one and based only on *Test II—Technical Verbal Ability, Test III—Comprehension of Scientific Materials,* and *Test IV—General Mathematical Ability.* The following tabulation presents the range of correlation coefficients between test scores and first-semester grade-point average and median correlation coefficients for each test. These follow:

		Range	Median
Test I	General Verbal Ability	.16–.50	.38
Test II	Technical Verbal Ability	.25–.55	.47
Test III	Comprehension of Scientific Materials	.41–.65	.55
Test IV	General Mathematical Ability	.51–.71	.62
Test V	Comprehension of Mechanical Principles	.30–.55	.39
Test VI	Spatial Visualizing Ability	.22–.42	.35
Test VII	Understanding of Modern Society	.25–.53	.41
Composite Score		.44–.68	.62

The variations in correlation coefficients among a group of colleges of engineering are indeed striking. There are many explanations of such variations and no generalization will apply uniformly. Correlation coefficients themselves have limitations for purposes of interpretation and analysis. Sometimes it is necessary to resort to a consideration of the original data and to deduce from distributions of test scores and criteria why certain correlations are low or abnormally high. In many instances, it is not possible to explain such variations.

It does not follow, however, that such variations in correlation coefficients as are reported above negate analysis for purposes of projecting plans for a new series of tests. If we consider the median correlation coefficients for the several tests in the Pre-Engineering Inventory, we can conclude that the general mathematical ability test, the comprehension of scientific materials test, and the scientific vocabulary test are most predictive of grade-point average. This is as we would expect since success in engineering study in its initial stages depends very largely upon the student's mastery of scientific subjects.

While performance on the test of ability to comprehend mechanical principles is not highly related to grade-point average, scores on this test have been observed to correlate with grades in college physics courses to the extent of .51 and engineering drawing to the extent of .56. Although the correlation of general verbal ability with grade-point average is almost exactly that obtained for the ability to comprehend mechanical principles test, the correlation between the general verbal ability test scores and course grades in physics is .32 and in engineering drawing .15. Therefore, the mechanical principles test appears to be very much more valuable for predicting success in physics and engineering drawing than the general verbal ability test.

The spatial visualization test in certain institutions correlates with grades in engineering drawing to the extent of .67. Thus, this test predicts with unusual accuracy the student's achievement in engineering drawing, and while this subject is only one of the several subjects included in the first year of engineering study and is dissimilar in character to much of the work done during that year, it is nevertheless a prerequisite to descriptive geometry and to continued success in the engineering curriculum.

One finding reported in the above data is of particular significance to guidance officers and counselors, although it has less implication for the construction of the aptitude test. This is the fact that the understanding of modern society test is a fair predictor of first-term grade-point average. While there is considerable variation in their social studies courses and content in colleges of engineering, in many colleges considerable emphasis is placed upon this area of instruction. Thus, the guidance officer and counselor, when discusing the results of the aptitude test with prospective engineering students, should also point out that achievement in social studies during the last two years of high school will also be an important asset in the college of engineering. Similar emphasis may be placed upon the field of English, but since both social studies and English are generally required areas in the secondary school, at least through the junior year, the engineering aptitude test will not attempt

to provide achievement or aptitude tests in these areas. It should be re-emphasized, however, that the counselor and the student must recognize that an average or superior achievement in English and social studies will be a decided asset to the prospective engineering student.

V. Summary

The Measurement and Guidance Project in Engineering Education will construct and validate the first form of the Engineering Aptitude Test for High School Students during the next school year. This paper has been concerned with plans for developing the tests to be included in this series.

In summary:

1. It has been pointed out that there is a need for a guidance test at the high school level which will provide dependable scores for purposes of advising students of their potentiality for the further study of high school mathematics and science in preparation for the study of engineering. It is believed that this test should be administered during the sophomore year in high school when opportunity remains for students to elect further courses in high school science and mathematics.

2. General principles of test development were presented. These dealt with the validity of the testing instrument, the reliability of the individual tests in the series, and the difficulty of the materials to be included in the series.

3. The projected series of tests will include tests of three major abilities: (1) ability to comprehend and interpret scientific materials, including scientific vocabulary; (2) general mathematical ability; and (3) ability to comprehend mechanical principles. A test measuring spatial visualizing ability may be included in the series, or this test may be prepared as a separate, optional test.

4. Data concerning the validity of the several tests in the Pre-Engineering Inventory were presented. These data indicate the advisability of proceeding with the measurement of mathematical and scientific ability as the basis for an engineering aptitude test at the high school level.

5. Finally, it must be reemphasized that the results of such a series of tests must be interpreted in light of specific information concerning the prerequisites of engineering curricula and the nature of this field of study. It was pointed out particularly that superior achievement in high school English and social studies will undoubtedly prove a highly desirable asset on the part of the prospective engineering student.

Developing Creative Ability in an Educational System

By K. B. McEACHRON, JR.

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I. What Has Been Accomplished

Before discussing specifically the subject assigned to me this afternoon, I should like to review with you the engineering educational system and to recall its objectives and accomplishments in this field. With this as a background we can then better appreciate the problems of developing creative ability and more accurately determine their solutions.

The great and pressing need of industry over many years has been for college trained engineers who could analyze complicated engineering problems by reducing them to their simplest terms and applying fundamentals of engineering to their solution. The colleges early recognized this need of industry and have organized their curricula to meet it. As a result, the engineering curricula contain more theory in mathematics and science and more specific applications of natural laws to material things than any others. Because the graduate in industry has been more concerned with the analyses of machines and processes, the average college student has received much training in analytical methods. This objective approach to engineering and science has so revolutionized our thinking and views of education in general that we have described it as an entirely new method of learning and labelled it "The Scientific Method." The colleges and universities, of this country particularly, have pioneered in the training of young men and women in this new concept and our industrial empire is mute testimony to the success of these efforts.

Recently this Society and engineers generally have recognized that the engineer has a responsibility above and beyond that of producing materials and machines to raise the standard of living. He has also a definite responsibility to see that the products of his efforts are used constructively and for the good of *all*. The results of this new thinking are contained in the reports to the Society by its Committee on Engineering Education After the War and in the definite plan of many schools to include in the engineering curricula subjects with humanistic and social implications in addition to the technical and specific. This second demand of industry and society in relation to the education of engineers has thus also been recognized by educators generally and definite steps have been taken to meet it. In this area, however, the problem is not nearly so concrete nor the answers so obvious as in the area of purely tech-

* Presented at the 55th Annual Meeting, A.S.E.E., Minneapolis, June 18–21, 1947.

nical training. The shaping and molding of the attitude and philosophy of prospective new engineers is a much more difficult job than their technical training. We all recognize, however, what success in this attempt may mean, not only for the engineering profession but for society as a whole.

II. The Problem

The developing of creative ability is neither so specific as the acquiring of technical knowledge nor so nebulous as the creation of attitudes. However, the developing of such ability presents possibly an even greater challenge to engineering education than the developing of attitudes. Creative ability is not only a state of mind but also, in our society and in industry, a process of action. In a world where physical results are the chief measure of accomplishment and even of invention, creative ability is valued only when it results in new methods or new designs. Creative ability, therefore, might be considered to consist of two parts: mental and physical—creative and reduction to practice—and both are essential. An artist becomes great only as he places on canvas the pictures in his imagination; a creative writer is recognized only by his literary accomplishments; and a creative engineer will be acknowledged only as he reduces to practice his ideas.

Developing creative ability from the standpoint of education is, thus, a problem which requires more emphasis on the actual construction of devices than the normal engineering curriculum and a mental training of a character substantially different from that of a normal curriculum. To complicate the problem still further, creative ability can be developed most successfully only by individual attention. As is true in almost any field, the creative mind does not lend itself to systematized training and the developing of such minds can therefore be approached only with a sincere appreciation of this fact and with the attitude that the educational system must be altered wherever necessary to meet the need.

III. Fundamentals of the Problem

The training of people at any level and in any field consists of selection, training, and placement. Although the engineering college is clearly responsible only for training, its success in this area will be obviously effected by the selection of those to be trained, and perhaps to a lesser extent upon the placement of those previously trained. Because there generally is a serious lack in industry of men with creative ability, there are ample placement opportunities during the foreseeable future. Our interest at the present time, therefore, is mainly concerned with selection and training.

A. Selection

The best engineer is one who not only has creative ability but also has a considerable amount of competence in engineering analysis. Those who have some competence in both the creative and analytical fields will for the most part, graduate from high school successfully and qualify for admission to colleges and universities. Careful guidance and counseling of these men in their freshman year should uncover their dual abilities and interests and encourage maximum development in both areas. There are, however, a larger number of men who have a considerable amount of creative ability with very little proficiency in

analysis. Because our educational system from the grammar school through the college is primarily based upon analytical achievement, such men may finish high school with poor records, if they graduate at all. The selection of those with creative ability, therefore, cannot be adequately accomplished only at the high school graduate level. It is a job which must be begun in the first grade of grammar school. Some attempt must be made during this period and the high school experience to encourage those with creative ability to develop their natural talents rather than to stifle them with more and more theoretical and analytical techniques. However, it is clearly impossible for the colleges to reach much below the high school graduate. Primary and secondary schools must accept their responsibilities in this matter and must work with the colleges to insure the continued development of creative people. We cannot, however, understand the whole problem without recognizing that the selection of young people with creative ability is not a question which can be completely answered by selection at the college level.

Mention should certainly be made at this point of the technical high school which gives students greater opportunity to use their imaginations in the design and construction of small devices. Although the curriculum is still predominately specific and analytical in character, most students who have any creative ability will have sufficient opportunity to demonstrate it during their high school experience. Thus, in the better technical high schools, an attempt is being made, while continuing the training in science and mathematics, to encourage the application of creative imagination to problems in the design of small gadgets.

With the exception of the technical high school experience, the college that is attempting to determine which of its freshmen has creative talents has little educational background on which to base its decisions. In fact, it may be obliged to discount much of the scholastic attainments of the average high school graduate if it sincerely desires to select those with such abilities. Usual aptitude and intelligence tests are almost as useless. There is some hope, however, that with the development of subjective tests such as the Rorschach, some definite criteria may be established for the selection of such people. Improved guidance counseling, particularly in the freshman year, can accomplish a great deal in discovering those with creative abilities. One of the most definite indicators available to the colleges of such ability is the nature of the hobbies and outside interests which students have pursued. There are few boys without some interest in mathematics, electricity, or chemistry. There are, however, relatively few who have such a high degree of interest that they will overcome physical difficulties to have their own machine shop or laboratory where they can rebuild automobile engines or make power plants for boats or model aircraft. Even here, however, it is not always possible to draw the same conclusion from the same apparent set of facts. Two boys may build the same piece of equipment but one may build it from a standard purchased plan and kit where the other may develop his own design and obtain his own materials. Economic circumstances may be responsible for this difference but often it can be traced to the difference in interests. Both may

be builders but only one may have a creative imagination.

The selection of men with creative ability is a difficult but rewarding job. It further is absolutely essential if any degree of success in the developing of creative ability is to be obtained. What experience we have had in industry indicates that creative ability cannot be taught but can only be developed.

B. Training

Creative ability can best be developed by an apprentice system where young men can work with designers whose imaginations and abilities have been well demonstrated over many years. This apprenticeship is particularly valuable if there is an opportunity for each "apprentice" to work with a number of different "masters." He may then catch something of the approach and method of each from which he will develop his own individual plan.

In addition to such assignments each student should appreciate and understand the fundamentals of engineering and be able to apply them to actual engineering problems. However, this classroom instruction should be much less intense and with more emphasis upon the simple fundamentals than the average engineering course. The seminar type of instruction rather than lecture and recitation is much more effective here. The purpose of the study of such fundamentals is to insure that proposed changes for new designs are actually workable and practical to manufacture. Class problems should be designed to develop the young engineer's ability to translate his creative ideas into workable designs.

During the period of training, each young engineer should have an opportunity to develop, design, and construct at least one device of his own choice with the guidance and assistance of an outstanding designer. This project may not involve any ideas original to the art but rather a combination of old ideas which is new at least to the student. Such a project is similar in many respects to the senior thesis which many schools have eliminated. Insofar as the development of creative ability is concerned, the project or thesis type of course is the only real opportunity a student has to try out his own ideas.

IV. What Can the College Do Now?

Most of the aspects of the trend to develop creative ability in young engineers seem more adapted to industry than to the colleges. This, I think, is basically true. Industry will always have to recognize that the colleges cannot be expected to develop creative ability in young engineers in a very complete way. There are, however, several specific steps which most colleges can take to insure that, first, those with creative ability are not eliminated from the school entirely or so forced through the normal educational pattern that their college experience is largely valueless, and second, adequate opportunities are given them to demonstrate their intuitive abilities.

Because the problem is one which so vitally concerns industry and which no matter how successfully begun in college must be continued and extended in such industry, it is essential that plans for stimulating creative ability in a college curriculum be made in cooperation with representatives of industry. To be effective, such representatives should be themselves creative designers rather than adminis-

trators. They should, with representatives of the engineering faculty, constitute a board of advisors whose active and continued interest in the program will have more effect upon its success than any other factor. The representatives of industry should also be carefully selected on the basis of their interests in education generally. Although such a board would probably have no official status, it should nevertheless be kept continuously in contact with the curriculum by regular and frequent meetings at the school or at the plants of the industries represented. If such a board is properly selected, it need be given no charter nor any proposed plan. It will quickly and enthusiastically develop its own. There are, however, some general suggestions which it will probably propose.

A. Design Projects

Most courses in design in present curricula consist of analyzing and testing equipment which has already been designed and constructed. Such courses do acquaint young engineers with the type of equipment they may be expected to work with in industry. However with the exception of the most basic machinery, individual designs of equipment differ widely from one manufacturer to another and the young graduate is not expected to be acquainted with such equipment when he is first employed. Furthermore, the college is expected to give the student basic rather than specialized instruction, and specialized design courses will often give the student an erroneous impression of what he may expect in industry.

Other types of design courses in many present day curricula consist of calculations of specific designs patterned after sample calculations. The student merely obtains practice in juggling the figures to obtain a slightly different result from that given in the text with no real conception of the engineering factors involved. The use of such data drawn almost verbatim from a text requires no original thinking. Such calculations would be much more effective as training if no textbook whatever were provided and the student was asked to make certain designs using his own method and obtaining his own experimental factors.

A third type of design is that which industry largely designates as drafting. Certainly the college does not expect to train experts in this field; yet many college courses give so much attention to detail drafting practices that the student comes to feel that design in industry consists principally of drafting work. Every engineer must certainly have a minmium amount of sketching ability and must understand the rules of perspective and projection but such training does not require the use of pen and ink or even a straight edge. With the pressure on the engineering curriculum for the inclusion of non-technical material, we can hardly justify retaining such design or drafting courses at least in their present form.

The training which all three of these types of design courses profess to give the student can be better and more effectively obtained through a single course which will further demand the exercise of some imagination and intuitive ability. Such a course would consist of the design and construction of small devices selected by the student individually after consultation with the class instructor. Too often in the past, thesis projects have been too large and complex and with too much em-

phasis upon original contributions to the art to be of maximum benefit to the student. The educational purpose will be better satisfied and more such projects can be included in a given class if such devices are small and simple rather than large and complex. The emphasis upon the thesis project is in most cases an emphasis upon research. By contrast, such a design course should stimulate the student's imagination and encourage him to make all sorts of "crack pot" devices. At least one college in the Southwest has scheduled this type of design class with the condition that only students who have demonstrated a certain minimum amount of ingenuity and who strongly desire to take the class will be enrolled. If such a design course is to be effective, it must be elective and not required. It is a serious error to force the unimaginative and purely analytical student into such training. It will not benefit the student involved and will seriously interfere with the training of the rest of the group.

The course proposed is not an easy one to plan or control. If it is to be successful it requires a considerable amount of personal and continuing attention from the college administration. Such design classes, however, will stimulate interest in design and development to an unusual degree, will give adequate opportunity for instruction in sketching and perspective drawing, and will acquaint students with industrial equipment of many varieties.

B. Participation of Industrial Designers

Because creative ability must be "caught rather than taught" it is essential that men with this ability be brought into as direct and continuous a contact as possible with practicing industrial designers and inventors. This may be done in at least two different ways. Such men should be invited to visit the school and work with the students in the laboratory and shop, discussing with them individually their projects and problems. Ample opportunity should also be given for these men to speak to the group as a whole describing their particular approach to the problem of creative design and describing in some detail the design process in their respective industries. Students and faculty alike will be inspired by a first-hand account of the design of a new material or device. Most industries will welcome the opportunity to participate in a program of this kind and will make such men easily available to the schools. To make frequent visits of such men to the schools reasonable, local and nearby industries should be considered first as a source of supply.

C. Faculty Preparation

Since most faculty members have had little opportunity to exercise their own imaginations in terms of design, it is essential to provide some method whereby those responsible for the training and guiding of these embryo designers may develop their own creative ability. In some cases, this may mean spending a considerable period in industry in design and development sections where such intuitive abilities are required. In many cases, there will be no men on the staff who have such ability and the college must look to industry to supply them. In the past, such men have naturally gravitated to industry because of the lack of opportunity to exercise their talents in the educational system. If a real attempt is made by the schools to de-

velop those students with some measure of creative ability, creative designers with an interest in education may be expected to consider favorably entering the teaching profession.

A program for developing creative ability in an educational system will be ineffective without adequate supervision and instruction. This part of the problem, therefore, is of primary importance to the success of the whole.

V. Design for the Future

Because of our pre-occupation for the past many years with the education and training of men in theory and analysis, we cannot look for immediate results in the developing of creative ability. As suggested earlier, the primary and secondary schools as well as the colleges have a responsibility to discover and develop such ability which in no part of the education system has, as yet, been adequately recognized. The Society is to be congratulated in this connection for its interest in this field and for its desire to do something about it. We must expect a long and difficult period before any measurable results in terms of adequately trained students can be looked for. The need of industry for men with imagination and ingenuity has been steadily increasing as its needs for analysts and theoretically trained personnel have been more nearly met. We can anticipate that in the future, this need will become more intense; and the developing of creative ability in college students must be begun at once.

The lethargy of other parts of the educational system should not be an excuse for lack of action by the colleges. Within their own sphere, institutions of higher learning can take many steps to further the development of creative ability.

However, in the process of stimulating ingenuity in the educational system, we must not overlook the fact that the ingenious designer is still fundamentally an engineer and must have an understanding of the fundamentals of engineering. Furthermore, he is interested in the same areas of activity as the other members of his class. It is, therefore, a grave mistake to establish a separate curriculum or to segregate those with creative abilities from the rest of the group except as their natural interests and desires dictate. A program to develop creative ability should be a part of the regular engineering curriculum and not apart from it. There is no excuse for establishing a separate curriculum and the entire program will only be harmed thereby. Because true creative ability is not confined to a specific area of engineering it cuts across all phases of the engineering field and unifies and integrates rather than segregates or partitions engineering training. A program for the developing of creative ability in an educational system must therefore be one common to all engineering fields if it is to be most effective.

In the last analysis, a creative designer is one who brings to bear all of his knowledge and all of his imagination to the solution of a complete problem no matter how many separate fields may be involved. The broader the training in engineering, the more opportunity there exists for the development of creative ability and the stimulation of ingenuity.

The Philosophy and Curricular Content of a Graduate Program in Electrical Engineering*

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In asking for a paper for this joint session of the Graduate Division and the Electrical Engineering Division of this society, your chairman mentioned the fact that a number of colleges throughout the country are expanding their graduate programs and that the point of view and experiences of a department that has carried on graduate work for many years might be of interest. In accepting this invitation, I am under no delusions that we have all the answers or that the answers we think we have to the problems of graduate study are the only ones, the best ones, or even right ones. Education at the advanced levels remains much more of an art than a science, guided by men and ideals. Because men and ideals are the primary and determining elements in the value and effectiveness of a graduate program, I propose to devote the major part of this paper to these, leaving rather minor emphasis on the subject of programs of study.

Please do not misunderstand me in this statement. I do not think that study programs are of no importance at the graduate level. Rather, I believe that men and ideals are far more important; and that if these are of suitable character and level, the questions of study program will in the normal course of events be given their due emphasis and study, with a result that one can justifiably expect to be soundly conceived and adequately planned.

In accord with this point of view, I propose to approach the subject of this paper as follows. First, we shall consider the objectives of graduate study in some detail because these are the necessary foundation on which to base any discussion of methods, study programs, staff and facilities associated with a graduate school. These objectives are illustrated by comparing characteristics of work at the undergraduate, Master's, and Doctor's levels, and by examining how typical graduate study fields contribute to these objectives. Second, graduate work imposes certain requirements as to staff, facilities, and adminstrative policy that must be recognized and faced if a school is to undertake a serious graduate program. These requirements are discussed. Third, there appear to be certain broad characteristics in terms of which one can describe a graduate study program. These I should like to present for your consideration.

* Presented at the 55th Annual Meeting, A.S.E.E., Minneapolis, June 18–21, 1947.

As the point of departure, we ask the question, "What is the purpose of graduate study?" The ready answer to this question is "specialization." While in a certain broad sense this is true, I believe that the educator who goes no deeper misses the true spirit and purpose of graduate study. In support of the "specialization" objective, an observer of my own department can very easily cite, for example, special graduate curricula formulated, with many a discussion, to meet certain supposed clearly specified and defined objectives for officers of the Armed Services. There is some truth to the idea that gradute work achieves specialization. Nevertheless, I hold strongly that this is a rather superficial and obvious aspect of what a graduate teacher seeks to accomplish.

The real objective is to lead the student to a more profound and thorough understanding of elementary scientific principles and to assist him in developing that mastery both of principle and of method of attack which will enable him to lead out in new fields with greater competence and assurance.

Here I should like to refute once and for all the widely held notion that graduate work in electrical engineering is conceived as primarily preparation for research. Rather, graduate work is conceived as helping a man better to tackle any engineering job requiring a fresh and fundamental approach, as contrasted with competently applied well-known methods.

Interestingly enough, the apparently "specialized" graduate subjects bring to the student the realization that his supposed understanding of elementary principles is restricted in scope and hazy in concept. This realization sends him back to restudy—with greater purpose and more critical perception—the first principles, of which he had previously assumed he was the master. Masterful grasp of first principles is cardinal. How often has each of us observed that the leader in science or its applications in engineering is characterized primarily by his ability to strip the complications from an apparently complicated situation or problem and to bring clearly into focus the simple elements that are its core. Such ability is more valuable than any amount of merely specialized knowledge.

"The "advanced" or "specialized" graduate subjects do, of course, provide a certain readiness of technique. These may be immediately useful and sometimes attractive to an employer, but the enduring result of graduate study is the deepening of understanding and the developing of that competence and assurance that enables a student to recognize and apply basic principles in new and different situations.

One may enlarge upon this point by a comparison of the undergraduate, the Master's, and the Doctor's level of work and outlook in engineering. Most of the undergraduate student's time and effort is devoted in the professional area to learning and making simple applications of elementary principles of mathematics and physics. The teacher often guides the student, sometimes in great detail. The problems which he is given to solve as a medium of learning principles do not vary too greatly from those discussed in the text or by the teacher. The good undergraduate teacher, of course, continually strives to make the student take steps by himself, but the less inspired teacher is prone to tell rather than to stimulate. Occasionally,

through the medium of comprehensive examinations or an undergraduate thesis, the undergraduate student is presented with problems of broader scope and further removed from his previous experience than the usual home problems. By and large, however, the undergraduate student sticks reasonably close to the beaten track along which he has been led by his instructor.

The beginning of graduate work can well mark a certain discontinuity in the student's experience in regard to the amount of thinking he is expected to do for himself and the general professional level of his accomplishment. The problems that he is given should be stated in more general terms and as a consequence require more thinking and judgment for the formulation of their quantitative aspects than the problems to which he has been accustomed as an undergraduate. He should be expected to have to go to the literature for assistance and even for basic text material more frequently than he ever did as an undergraduate. In the Master's thesis, if he is required to do one, the problem should be of substantially greater scope and difficulty than can be required of an undergraduate. In all these aspects the emphasis is thrown much more strongly in the graduate year on individual initiative and thinking.

At the doctorate level this stress on individual drive, initiative, and self-reliance is again increased. The doctorate student is almost by definition one who has a large measure of ability to formulate and pursue, at an independent and scholarly level, work of an advanced character. This does not mean that he works in isolation without the aid of his professors and associates. Rather, he consults with them on a personal and professional basis as one who, having already studied a problem and clearly thought out all of its straight-forward aspects, has singled out and defined the more advanced phases requiring creative thought and seeks the benefit of mutual discussion. Here the teacher's function is that of a counsellor as to broad objectives and general lines of attack, who offers the benefit of perspective stemming from his experience. Detailed guidance would rightly be resented by the student.

Thus the later stages of the doctorate program, though necessarily associated with a specialized subject or area, are significant not because of this specialization but rather because of the relatively mature development of the student's skill in applying the scientific method, his profound understanding of fundamental principles, and his ability to carry through independent, creative, and productive work on his own initiative. The soundness of this concept was demonstrated brilliantly in unnumbered cases during the recent war, in which civilian scientists trained in this philosophy made outstanding contributions in record time in fields quite unrelated to any previous area of "specialization." Their previous "specialization" had served as the *medium* of training, not as its *end*. The concept of the doctorate as a final stage in the process of learning "more and more about less and less until one knows everything about nothing" is unsound and productive of persons of very limited usefulness. This does not mean that profound knowledge and competence in a particular area are not worth while. In fact, the great advances in science are made by people in precisely this position. However (and this seems to me very important),

the capacity for independent and resourceful creative work stemming from a profound grasp of fundamental principles is the primary characteristic of the people who do this work; the specialized knowledge is basically incidental. Such persons rapidly develop specialized knowledge in any field in which they need it.

This specialization-versus-deepening aspect of graduate work is well illustrated by the experiences of students working in some of the fields which are currently popular in electrical engineering graduate study at the Massachusetts Institute of Technology.

Servomechanisms and automatic control constitute a very popular area. This field sounds very specialized—so specialized indeed that the casual observer could legitimately question whether, in teaching it, one has not forsaken fundamentals for *intensive* specialization. Almost paradoxically we find in practice that it becomes an extraordinarily effective medium for deepening and broadening the grasp of fundamental principles, an experience that I believe many of you have shared. Thus one immediately comes face to face with the dynamics of lumped-parameter systems including active elements. Questions of dynamic stability and of detailed behavior under transient as well as steady-state conditions must be answered quantitatively. One finds that the steady-state response to periodic driving forces over a broad frequency range is equally important.

This type of analysis, of course, requires the accurate description of the behavior of the significant elements in terms of differential equations, one of the most difficult and simultaneously most important components of the engineer's discipline. In a servo system one encounters separately or in combination such apparently diverse devices as: electric circuits including electronic devices; hydraulic amplifiers, pumps, motors, and transmission systems; pneumatic systems; and electromechanical devices, including motors, generators, torque motors, selsyns, multi-winding amplifier generators; to say nothing of the chemical, thermal, aerodynamic, mechanical, or other systems which are integral components of closed-cycle systems for the control of such quantities. The servo man must be able to deal quantitatively and analytically with the dynamics of such varied components and of complete systems involving them. At the design level he must understand basic possibilities and limitations with a perception that permits radical departures from previous practice. Thus the servo field is one that compels integration of mechanics, hydraulics, and electric circuits in a way that is a joy to the educator.

Another integration growing out of automatic control is that between the closed-cycle control system and what the electric network people have long called the feedback amplifier. In fact, most of the basic ideas of feedback-amplifier theory carry over to the closed-cycle control theory. Thus the student of servomechanisms and automatic control is required to consolidate his elementary theory of lumped parameter dynamic systems so thoroughly that he recognizes its earmarks wherever he may encounter them.

Another area that has achieved very wide popularity as a result of the war is that of microwaves. No other subject has been nearly so effective in sending the electrical engineering student back to Maxwell to learn the basic physics of electrical engineering,

namely, electromagnetic field theory. The radar and other pulse system applications, most of which are at microwave frequencies, have also enforced the need for a clear understanding of simple resistance, inductance and capacity circuits and electron tubes under transient as well as steady-state conditions.

As another example of the "specialization" route to fundamentals, the field of electric insulation—so long forced to progress along empirical lines—is now beginning to draw direct and fruitful support from physics and chemistry at a level that suggests, for the not too distant future, synthesis of materials designed on the basis of atomic, molecular, and crystal properties to meet specific requirements. This applies not only to insulators but to semiconductors, nonlinear circuit elements, certain electromechanical elements, and photo-sensitive devices, to mention a few.

These examples in the field of servos, microwaves, and insulation are illustrative of the way in which relatively borderline fields which are good subjects for graduate work throw the student back to a deeper and more thorough understanding of the underlying science than he has had to achieve previously. In many cases the graduate student sees that with the help of more mathematics and physics he will get a deeper understanding of his engineering principles. Thus the whole spirit and trend in graduate work, when it is challenging and stimulating, is to develop a greater appreciation for and competence in the underlying science, and at the same time to provide a certain amount of "specialization."

Of course there are those students of restricted horizon and limited capacity who persist in graduate work and who see the specialization aspect but never quite grasp the deepening influences. Such become the graduate counterpart of the undergraduate who, having taken one professional subject in machine design, concludes therefrom that machine design is all he ever hopes to do throughout his life. They are members of the graduate-school community in name but not in spirit.

Before leaving this subject of the objectives of graduate study, I should like to touch upon an aspect that is receiving increasing attention at the graduate level parallel to the major attention at the undergraduate level. This is general education, including the human-social stem. This we all know is a large subject, too large to more than touch upon here. Nevertheless we should all be acutely conscious of what can be one of the hazards of graduate work, namely, the too exclusive emphasis on the quantitative and rigorous aspects of science and engineering. Such emphasis—to the exclusion of broad outlook and of humanizing influences—can reach the point where the student is abashed and clumsy, if not entirely uninterested, in those larger, complex, and inexactly understood problems of engineering and of human affairs in which careful weighing of conflicting evidence and human values rather than mathematical methods are the basic elements. Leadership cannot ignore, in fact must give primary attention to, such problems. Leaders are scarce in all fields of activity, including engineering. I think we should make a serious effort, at the graduate as well as at the undergraduate level, to enlighten the student of restricted outlook who would ignore any problem that cannot be solved in terms of equations or numbers. As a matter of fact,

even in engineering and science close logical reasoning and mathematical analysis are prehaps more often used as a means of exploring, bounding, or verifying some imaginative person's bright idea for solving a tough problem, or of explaining an unexpected experimental result, than as the means of discovering new ideas. That is, imagination usually runs ahead of and leads the way for the more systematic and orderly process of mathematical thinking. Some of us educators would feel happier if more of our Sc.D's were potentially fitted to step into their bosses' places, where broad thinking is required.

Surely, then, we should in graduate as well as in other levels of engineering education avoid that one-track emphasis on the mathematical reasoning that leaves the student unmindful of or unsympathetic toward the more imaginative aspects of his profession, and toward the even more important qualities of personal leadership. Leadership involves broad interest, sound judgment, and clear perspective, as well as energy and productiveness. Certainly in graduate work we should encourage and develop these qualities of leadership as well as professional competence in the restricted sense. How to do this is another and far more difficult subject to which all of us need to give thought. The influence of strong able men as graduate teachers is one of the more obvious ways. We cannot solve this age-old problem here, but do reiterate its dominant importance.

Having thus far considered at some length the objectives of graduate study, I turn next to the second main part of this paper, namely, the prerequisites to a graduate-level educational program. In this I wish to emphasize again that graduate work is not just another year in the undergraduate manner. A school may do a good undergraduate job and still lack that which is the essence of the graduate spirit. One cannot have a graduate school by merely willing that one shall exist or by applying a name. Certain conditions are, I believe, essential to achieving a graduate-level program which I shall try to describe in the following paragraphs. These requisites are:

1. Suitable staff
2. Qualified students
3. Administrative support

The first prerequisite, *suitable staff*, is undoubtedly the most important single element because without it one can do nothing, whereas with it one is likely to be able to find the other requisites. The outstanding qualification for a staff member for graduate teaching is that he shall be creative-minded. He must be interested in new ideas, have a large amount of intellectual curiosity, and be personally active in or associated with creative professional work of high quality. Only from such a man can the graduate student catch the pioneering spirit. Only occasionally does one find a man who maintains the level of curiosity, scholarly interest and mastery, and intellectual alertness to do well in graduate work who is not personally active in professional or scientific work. Such a man can be a good supporting member of the team, but the essential spirit comes from those who are themselves creative workers.

In addition to being a creative-minded person of real productivity, the graduate teacher—in common with all teachers—should enjoy associating with and developing young people. He

should experience that satisfaction in teaching that any devoted teacher feels to such an extent that he is not happy without a class or some active association with students. Such a teacher incidentally brings vigor and freshness to his undergraduate students, an important influence that a graduate school exerts on the undergraduate school.

There are undergraduate teachers, concerned primarily with people and with teaching for its own sake, who apparently have exerted great influence over their students, but who at the professional level merely keep reasonably abreast of what is going on. They derive their satisfaction from watching young people rise to the thrill of seeing for the first time and understanding ideas which, though old, are new to them. Such a teacher often has a flair for showmanship. He enjoys watching the pattern of student interest develop each year as he tries new tricks and varies his teaching approach and technique from year to year with the idea of seeing what makes the students respond best. Such a teacher is often revered for his personal wisdom and richness and is undoubtedly a great influence in the lives of the undergraduates whom he teaches. Such a man, however, lacks the essence of the graduate teacher, who needs above all to have that spark of imagination, curiosity, and restlessness of mind that keeps him continuously exploring into new territory. One cannot have a graduate teacher, merely by assigning supposed graduate work to one who by aptitude and nature is an elementary undergraduate teacher. Successful graduate work requires that the students experience the personal influence of one who is dealing intimately with the frontier of knowledge in some part of the field.

The second requisite for a graduate program is a suitably qualified group of students. Graduate work is more exacting, both in pace and in depth, than undergraduate; hence only those students whose general intelligence, background and specific preparation are high should be accepted in a graduate school. Such will probably not be found below the top third of a strong undergraduate group. These qualifications are necessary in order that the graduate pace and standard may be maintained. The real graduate spirit, however, comes from those who have something more—those who have imagination and rise with enthusiasm to new and challenging problems and ideas. These must have the intellectual character to think independently for themselves. They are willing to challenge the teacher when he appears to be on unsound ground, a challenge incidentally which the real graduate teacher welcomes as evidence that his students are learning to think for themselves. As these students begin to have ideas of their own, their teacher enters his period of reward—that of seeing them gradually develop competence and then confidence to tackle and solve serious and difficult problems requiring new thinking. It is for this kind of student that the graduate school primarily exists. The intelligent but unimaginative person may benefit, but he is essentially an "also-ran" in the graduate school. This second requisite is, then, a student body whose minimum of intellectual qualifications is high but which includes a substantial fraction of those having the mettle and spirit of creativeness.

The third of the three requisites for graduate work, *administrative support,* is almost equally as important as the

other two. Administrative support expresses itself in a variety of ways. First, and foremost, it recognizes the creative type of staff required for graduate work and provides the environment that is requisite to securing and sustaining the creative activity of such a staff.

Most important among these enenvironmental factors are suitable teaching loads and the opportunity for individual professional work either within the institution or in consulting for industry or government. Graduate teaching requires much more preparation than undergraduate teaching. In this statement I am assuming that even the undergraduate teacher of competence has few pages in his working notes that are more than a few years old. The graduate course that is given twice without change is becoming stereotyped, while a third repetition means that decadence has set in. It takes time and study in generous measure to conduct a graduate course worthy of the name. If the administration persists in including graduate teaching as a part of a heavy teaching schedule, the result is simply stated: The graduate course ceases to be a graduate course.

Comparable in importance with suitable teaching loads as an environmental factor is the opportunity for individual professional work. We are here talking not about the pot-boiling work of routine character but rather about the research or professional consultation that requires and challenges the best efforts.

Research programs within the institution that are well integrated with graduate work can be a very valuable influence and opportunity. Administrative support of such programs thus becomes a great aid to graduate work, both by attracting and encouraging suitable staff and by providing opportunity for staff and graduate-student participation in live and going projects. Such research must be worthy of the name, that is, must involve real and new problems in contrast to glorified testing programs that occasionally are dignified by the term research.

Consulting can furnish equally valuable intellectual nourishment for the staff and live subject matter for students, though it usually lacks the opportunity for direct student participation.

We all know that "light" teaching loads and opportunities for outside professional work or research can be and occasionally are abused. This has no pertinence to their essentiality for the graduate teacher. It merely means that character, conscience, and a sense of fitness are as important in the graduate teacher as in any other person to whom is entrusted a large measure of freedom and responsibilty.

Another way in which administrative support is required, though I suspect this is far less of a practical problem than those factors we have been discussing, is student selection. Any faculty group that is charged with the responsibility for administering a graduate program must have substantial autonomy in selecting the students it will admit to graduate work and in setting standards for degree recommendations. The problem of administrative support here is probably less difficult at the graduate than at the undergraduate level but it is nevertheless important.

Finally, administrative support is essential in the matter of physical plant and facilities, particularly laboratories and the library. The graduate student who is to do experimental investigative

work must have space, he must have equipment, and he must have access to shop facilities. The equipment need not be elaborate, though the lack of some types of expensive equipment may automatically bar certain lines of investigation. Access to shop facilities is probably more important than extensive equipment, since the good experimenter can almost be defined as the one who, given access to the storeroom and a reasonable stock of materials, can devise much of his own equipment. Of course if one has, through institutional, industrial, or governmental funds, the opportunity to have well-developed and instrumented laboratories, the student is spared some of this effort together with some of the valuable education that goes with it.

Among physical facilities an adequate library must be recognized as one of the most vital to graduate work. This library must be easily accessible. Preferably it occupies space contiguous to the laboratories, classrooms, and offices of the staff. A working library for a department giving graduate work at the Master's level should include all of the standard texts and references in the field as well as the principal works in adjacent fields, such as mathematics and physics. In periodicals, a good coverage of domestic journals should be included plus a few of the more important foreign periodicals. For doctorate work none of the reasonably useful domestic or well-known foreign periodicals can be omitted. Also, the coverage in the underlying sciences should include those items to which the inquiring graduate student will want to refer.

In the library, as elsewhere, staff quality is cardinal. A library without an able and enthusiastic librarian is like a laboratory without a good instructor. In either case the physical facility alone has little influence on student thought and education. With able leadership each becomes an inspiring and influential teaching medium, the library being quite commensurate with the laboratory in importance.

In the foregoing discussion of requisites for graduate work, the first—and the one to be most emphasized—is suitable staff. Certain qualities were stressed as of prime importance. How can one determine these qualities? What tests can one apply to a prospective graduate teacher to ascertain whether he has these qualities? There are three tests that are obviously significant. They are: first, the candidate's standing in the profession; second, his interest in education; and third, his personal qualities.

What are the evidences of standing in the profession? One evidence, which I wish to qualify carefully because it is so easily misunderstood and abused, is professional publication. The abuse can occur when publication is made a requirement for, rather than an evidence of, professional standing. The natural response to the requirement of publication as a qualification is that an ambitious person will publish, and publish voluminously, whether he has anything worth publishing or not. We are probably all familiar with this sort of perennial author. On the other and positive side, however, it is clear that professional publications that are recognized as worthwhile contributions by workers in the field are meaningful evidence of professional competence and activity. That is, to regard publication as an absolute requisite is erroneous and dangerous; to regard good publication as tangible evidence of ability is sound. In the absence of good publication,

however, one must insist upon alternative evidences of professional competence and vigor. Another criterion of professional standing is the record of a person's activity in industry, in consulting, or in other forms of engineering practice. Such a record should show rather important responsibility ably and imaginatively discharged. Mere competent carrying-out of recognized engineering procedures is not sufficient. There should be clear-cut evidence of personal contributions of such sort that publication, if appropriate, would be clearly merited.

The person who is known solely as a good teacher, though he may do good and valuable work, does not bring to a graduate school one of its absolutely essential components, namely, personal participation in a creative engineering activity. This staff qualification of personal participation and creative engineering activity is stressed very heavily, because only when this type of thinking is present are the conditions met that make graduate work more than a prolongation of undergraduate learning.

What about the Doctor's degree? The answer is that a good man often has one. Also the holder of the doctorate is often a good man. To go further than this is to invite confusion between the clothes and the man. All too often the degree is regarded as the magic touchstone that eliminates the need for a searching and critical appraisal.

The second criterion for a successful graduate teacher is that common to all teaching, namely, a devotion to teaching activity. It is the joy in seeing young people grow and in assiting them to grow. Neither creative ability nor devotion to teaching alone can provide the essential graduate spirit. Both qualifications are essential. The degree to which a candidate for graduate teaching meets the second requirement is usually readily determined by the candidate's own expressed interests. Very few persons will say they like to teach if they do not, in fact, enjoy it.

The third criterion, personal qualifications, is at once difficult to formulate and important to apply. The student emulates those whom he respects and ignores those whom he does not respect. Those whom he emulates must be worthy of emulation in character and in person. They set the tone of the school. Those whom he does not respect contribute little to the student and are a dead weight on the standing of the school. By "respect," I of course do not mean the outward manners of deference that students naturally accord the position rather than the man. I do mean the appraisal that the students reveal among themselves in their private and brutally frank dormitory sessions. I have much confidence that able graduate students distinguish cannily between the mere "good fellow" and the man of intellectual substance, character, and power.

Having considered the "philosophy" part of the paper in terms of the objectives of graduate study and the requisites to their achievement, we turn briefly to that part pertaining to curricular content. Space does not permit much more than an enumeration of the important characteristics of a graduate program in electrical engineering, this subject being quite sufficient for a paper of its own. However, mention of the highlights will perhaps give an indication of how the foregoing philosophy is embodied in the program of a graduate student

at my institution. These characteristics are the following:

1. *Individual Treatment of Students*

Because of the widely varied backgrounds, preparation, experience, and interests of individual graduate students, an individual program devised after a deliberate and thorough study of his needs jointly by him and a wise faculty advisor is about the only sound solution of the graduate curriculum question.

2. *Individual Unified Program for Each Student*

Good integration of individual courses toward a central interest is required to attain the objective of depth in graduate study. The scope permitted by this objective is normally broader for doctorate than for Master's work.

3. *Relatively Few Simultaneous Responsibilities*

Serious graduate study is incompatible with more than a few simultaneous responsibilities. A maximum of four or five courses, and these not unrelated, are enough at the start, grading to one or two major activities near the end of a doctorate program.

4. *Reinforcement of Gaps in Preparation*

Insufficient preparation for graduate subjects should be frankly recognized as such and corrected by needed preliminary undergraduate work, rather than have the student attempt to do advanced work without adequate grounding, a procedure which usually results in a casualty either to the student or to the class.

5. *Further Work in Mathematics and Physics*

Many students at the graduate level sense the importance of further scientific grounding, an attitude to be fostered and encouraged.

6. *Advanced Professional Subjects or Courses*

These are what the average graduate student expects to take and automatically includes in his program.

7. *Interdepartmental Relations and Interactions*

Departmental lines should be considered purely administrative conveniences without intrinsic significance at the professional level, which students and staff should ignore in the pursuit of their scientific endeavor.

8. *Further Work in Expression*

We believe that continued emphasis on writing and speaking is justified at the graduate level, to the extent of requiring that every graduate student prepare and deliver a substantial professional paper of broad and critical character, the preparation proceeding through several drafts if necessary to attain a high standard.

9. *General Education*

The period of graduate study is not too late to strengthen and broaden interests and understanding outside of the strictly professional field; in fact, once aroused, the motivation in the graduate student is likely to be strong. We are actively experimenting along these lines.

10. *Modern Language*

For the Master's degree we require one, and for the Doctor's degree two, modern foreign languages of profes-

sional importance at the technical reading level. Recent experience shows that this skill can be attained in one term without prior preparation.

11. *Research*

We rate very highly the educational value of the skillfully supervised graduate thesis research, considering it the most important single component of the program.

Within the foregoing general specifications a mature advisor designs jointly with the student an initial program that is altered term by term as may prove desirable in response to changing student interest, to particular strengths or weaknesses that develop, or to other changing circumstances. This process we believe is far sounder than a set curriculum at the graduate level and is our answer to the graduate curriculum problem.

Summarizing this paper, I would again emphasize that the objectives of graduate work are to prepare students more fully for undertaking responsibilities departing from the conventional or routine areas of engineering. One thus prepares them by bringing them face to face with the need for a more profound study and understanding of scientific principles and with the necessity of thinking independently in terms of these principles on new problems. This, rather than so-called specialization, is the fundamental purpose of graduate study. In line with this objective, there have been presented certain conditions that may be regarded as essential to graduate education worthy of the name. These are: first and foremost, suitable staff with particular emphasis on creativeness; second, students having the attitude and qualities of mind that can benefit from graduate study; and third, adequate administrative support in matters requisite to graduate education. Certain criteria were stated by which one can test the qualifications of staff to train graduate students. The subject of graduate curricula was approached by giving a number of characteristics which the writer and his associates regard as important in designing graduate programs of study, among which the design of each student's program to fit his specific background, needs, and interests, ranks high.

In conclusion, we should carry on and develop our graduate programs not with the thought of producing cloistered specialists but with the ideal of implementing potential leaders in science and in technology and in the impact of these on the affairs of men. This we can do by helping these students to a deepened grasp on the power of the scientific method. We can develop in them the confidence that this method, when skillfully applied and when combined with a generous measure of human insight and wisdom, can contribute greatly to human welfare.

Functional Laboratory Courses*

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Introduction

Mechanical engineering education, concerned as it is with *developing power* and *making things,* naturally involves theoretical and experimental courses in each of these fields. The basic problems involved in the development of laboratories and laboratory courses in power subjects are duplicated in the manufacturing processes of metal cutting, forming and casting and in the design functions of stresses, vibration and control experiments.

In all cases it is fairly easy to state general aims and objectives, but quite another thing to develop the actual experiments, laboratory facilities, teaching staff and student attitude to really accomplish them. Since poor results are usually the result of ineffective execution and not of faulty intentions, this discussion will be concerned with some specific and practical problems of laboratory development.

Functional Laboratories

In far too many cases of laboratory course content is determined largely by the experiments that can be readily performed on existing or slightly altered permanent equipment. In entirely too few instances does it prove possible to design an experimental program to fit a given subject matter and then to build a laboratory to perform those functions. Mechanical engineering laboratories are too often in a position comparable to that of a factory with a fixed plant equipment and arrangement that is faced with constantly changing products and processes.

That nebulous group of ideas so blithely referred to as fundamentals is constantly evolving and because new and revised text books go to all schools, class room courses can be kept up to date without too much effort. Laboratories, on the other hand, have a disconcerting habit of not evolving and of lagging not just years but student generations behind in the functions they should perform. When laboratory revisions do occur they are usually widely spaced and painful upheavals that are, on the average, at least ten years overdue.

There must be some rather definite reasons why such a situation should constantly plague mechanical engineering educators and if there are reasons by the same token, there should exist at least partial cures.

Lessons from the Past

The experience of planning and reorganizing the laboratories of four departments of mechanical engineering and of working in a large industrial laboratory during the past seventeen

* Presented at the 55th Annual Meeting, A.S.E.E., Mechanical Engineering, Minneapolis, June 18–21, 1947.

years has resulted in the conviction that laboratory planning of the past has had some inherent weaknesses. It should be useful to list and study the more glaringly apparent of these faults.

(1) Individual pieces of equipment have been excessively large and space consuming, much too expensive and entirely too inflexible. There are certain possible explanations for this.

(*a*) Commercial equipment was generally used instead of developing apparatus especially designed for educational needs.

(*b*) There has been a distinct tendency to look upon laboratory courses as training in test procedures and not as an approach to education from the point of view of scientific experimentation.

(2) Use factors of equipment and laboratory space have been entirely too low. In general this is the result of two things.

(*a*) Again, the equipment has been excessively large, single-purpose apparatus originally designed for industrial and not for educational service.

(*b*) Valuable laboratory space has been occupied year after year by obsolete and unused equipment. In far too many laboratories it is possible to throw away a third of the apparatus without touching anything that has had appreciable use in five years.

(3) In medium and large sized schools particularly, there has been an ever widening gap between laboratory and class room teaching and teachers. This has produced two undesirable results.

(*a*) It has had the effect of concealing from students the complete interdependance between theory and experiment.

(*b*) It has increased the temptation to permit laboratories to become obsolete by making laboratory courses things that can remain unchanged even when the theory courses do progress.

Subject Matter Laboratories

Successive attempts have evolved a scheme which can be called a subject matter laboratory using small, flexibly arranged equipment that gives promise of avoiding many of the troubles previously listed. The general idea may be illustrated by discussing a laboratory devoted to the general subject of heat transfer.

To begin with, if it is one large laboratory space and not a group of small special purpose rooms, the space use factors can be much higher and the temptation to let fixed installations become obsolete is definitely reduced. Also, if heat transfer experiments at all educational levels including graduate work are performed in the same space with flexibly arranged equipment, the use factor of apparatus and instruments can be easily increased.

The disadvantages of having several student groups in one area is more than offset by the improvement in student morale and interest. Juniors doing a rather simple experiment may be working in the laboratory simultaneously with seniors or graduate students doing advanced work and this makes an almost miraculous change in student attitude and interest. It even brings about the very desirable situation of advanced students voluntarily aiding with the instruction of beginners.

The center of the air work in such a heat transfer laboratory could well be a double compartmented plenum chamber designed to meter almost any quantity of air depending upon the

number of nozzles opened up between the two compartments. As many as three independent fan or blower set-ups can be ready for operation on the inlet side and an equal number of tests requiring air can be in operation on the discharge side. Internal sealing doors can make it possible to close off all installations except the one in use and a complete change over to another test may be made in a few minutes. A junior test could be operating one period, a senior set-up the next, and at the same time a graduate research project could be in place.

Such equipment as heat exchangers, spray chambers, burners for hot gases, etc., would be portable units of the same capacity that could be put in place on the discharge side of the plenum chamber or arranged in any combination. By avoiding the use of fixed arrangements, permanently connected together, the temptation to permit laboratory equipment to become frozen and obsolete is greatly reduced. New arrangements to fit changing needs can be readily and cheaply made and a minimum amount of single purpose industrial type equipment would be used. There would be no real need for any unit to involve over ten horse power, so the total investment could be kept low.

The first step in the development of such laboratories is to hire about three good machinists. After going through each course to determine the points that need an experimental approach, the next step is to assign the jobs of evolving the necessary experiments and apparatus to the more ingenious and imaginative members of the staff. The surprise that always comes with such a development is the small portion of the resulting laboratory that uses standard commercial equipment. This is just as it should be, for the real purpose of experimental education is to teach the men who are to develop the next generation of equipment and not just to train them to test a past generation of apparatus.

Laboratories in General

This discussion could do no better than to terminate with a plea that real experimental education receive more emphasis in mechanical engineering. A changing point of view is clearly reflected by the disappearance of book titles such as "Experimental Engineering" and the appearance of books called "Plant Testing" and "Laboratory Manuals." Too often all instruction is done in theory classes and laboratory work is routine and laboratories are uninteresting.

A properly planned laboratory is a powerful teaching tool. Such things as partial pressures, characteristics of vapors, differences between internal energy and enthalpy, momentum concept any many other basic points can be best taught in the laboratory. Far too often the professor who lectures in a classroom is prone to think of the laboratory only as a place where younger teachers must toil out an apprenticeship biding the time when they will be admitted into the fraternity of theory teachers.

Engineering is an experimental science, not an accumulation of immutable laws, and generation after generation of textbook scientists could dry up mechanical engineering progress. Laboratory courses that awaken keen interest in both students and teaching staff are too few but not too difficult to realize. It is time to cease lip service to laboratories and make them into the vital educational influences that they are pretended to be.

The Place of Engineering Experiment Stations in Agricultural Engineering*

By ROY M. GREEN

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This cannot presume to be a discussion by an expert in the field of Agricultural Engineering. It is only intended to be an attempt to make an elementary theoretical analysis of the subject by one who has been a sympathetic observer of the trends of development in this field. For the purpose of this discussion the title should be changed to the general theme of the place of Engineering Experiment Stations in the full development of the Agricultural Engineering profession.

Argicultural Engineering

The whole profession of engineering is struggling for a place of maturity among the more stabilized and in some places more highly respected professions. Agricultural Engineering is one of the more youthful branches of the profession. Its youth gives it the virtues of enthusiasm and freedom from prejudice on the part of its members. It also poses problems of interest and importance for the consideration of its professional Society.

The American Society of Agricultural Engineers has been concerned with the matter of accrediting curricula in the various colleges and universities. The recent tentative solution of this problem by obtaining representation on ECPD accrediting committees and working cooperatively with other engineers and engineering educators seems logical. The matter of legal registration of Agricultural Engineers before the various State Examining Boards is another problem requiring careful consideration. It is hoped that a solution of this situation may come about through finding a means of cooperative action.

Professionia Development

Because the whole profession of engineering is relatively young and because Agricultural Engineeing is one of the more recently established branches of the profession it may serve us well to examine the basic elements necessary for the full development of any learned profession.

A well developed profession is the product of the work of specially equipped men. Special knowledge determines it identity. Motives or ideals give it spirit and direction. Ignoring the risk of over-simplification it is suggested that a truly professional motive should result in an intense feeling of compulsion leading to three forms of expression.

1. The urge to improve knowledge.
2. The urge to share this knowledge and its benefits.

* Presented at the 55th Annual Meeting, A.S.E.E., Minneapolis, June 18–21, 1947.

3. The urge for recognition among all men.

The Urge to Improve Knowledge

A profession is in its first process of development when its members are zealously searching for ways in which its special knowledge may be extended and improved. Professional men are, therefore, usually alert and responsive when asked to discuss the educational program of their particular calling. Each year the leading members of the various professional societies add to the volume of significant information which constitutes the knowledge peculiarly theirs. This compelling motive keeps the profession alive, and is therefore a primary necessity for professional existence.

The Urge to Share Knowledge and Its Benefits

Possession of the most profound knowledge of a particular subject field by those in a given group, however, has never earned for them the dignity of being a profession. A profession comes into being only after this knowledge is used for the benefit of others. The desire to share knowledge results in the two cumulative rewards: first, that of creating the best conditions for its own increase, and second, by making its values more universally recognized. We have, therefore, created professional societies to furnish an ideal place for sharing knowledge of new developments with others in our own areas of interest. The practice of the profession consists of making our knowledge useful in the lives of others. The value and significance of the service to others is the element which gives tone and dignity to the profession and justifies its existance.

The Urge for Status Among All Men

The members of any professional group are ill at ease so long as they feel other learned men do not appreciate the true value of their services. The whole engineering profession is in that state of development where it is not assured of this high esteem.. Because recognition has not yet been universally accorded we hear the complaint that few people know what the Engineer does and very few are willing to pay the engineer full value for his services as a fair return for his cost of education.

In this simple explanation of professional development please note that each of the basic urges leads to the next following. It is impossible to start with the third and work toward the first. When knowledge is increasing rapidly and is being liberally shared with others "status" among men will grow and the compensation of the practitioner will increase.

The Place of the Engineering Experiment Station

What is the place of the Engineering Experiment Station in this process of professional growth of Agricultural Engineering? The Engineering Experiment Station is the ideal agency to carry on the process of extending and improving knowledge in Agricultural Engineering. In the education of the student it is known that we teach best by example. If we expect our graduates to extend and improve their knowledge in professional work we should, by example, be enthusiastically carrying on the same process. One of the most obvious places to carry on this process is in the activities of the Experiment Station. If full development

of the profession is only possible through sharing with others the benefits of our knowledge we should be working on projects which are helpful to other groups of men. In our case these are the numerous groups who are vitally concerned with Agriculture from weather, soil and seed, to human food and manufactured product. It would then naturally follow that most of our projects would fall in the general classification of applied rather than fundamental research. The best and probably only way to obtain "status" is by becoming an important contributor to the solution of problems which confront other people. By finding some easier or quicker way of doing work or more profitable method of processing or storing our products or creating a more pleasant place in which to live we thereby lift ourselves in the esteem of others. This is the purpose of an Engineering Experiment Station.

Experiment Station Details

How can the Engineering Experiment Station do its best work? If the Experiment Station is to be of maximum value in working out applications in Agricultural Engineering it will be necessary to draw freely from the resources of many other men of science and engineering. Our problems are so interrelated that few really important projects can be adequately studied by drawing upon the resources of single individuals or from only one special interest group. It would seem that Agricultural Engineering problems could best be attacked where it is possible to call upon the resources of the physicist, the chemist, the bacteriologist and other men of science and upon the electrical, mechanical, civil and chemical engineer.

If maximum values to the Agricultural Engineering profession are to result from the activities of the experiment station, projects should be selected which are of vital interest to the people residing within the area of service of the station. There is no engineering school in the United States which is without vital and interesting research questions of particular significance to the welfare of its own region. Agricultural Engineering will have achieved national recognition when it has gained the high respect of the citizenry of each of the various regions. Support will be given agencies which earn respect through such constructive service.

To illustrate this theory we might use the region in which Nebraska is located. The peoples of our area are interested in the development of new machinery which would eliminate or decrease the necessity for "stoop" labor, such as potato harvesting and sugar beet harvesting. The cultivation of castor beans is increasing as an industrial crop. The development of a harvester for this crop would be helpful.

In the building field there is still a great possibility of designing for more economical construction for greater utilization of local building materials and the adoption of some of the newer construction materials to particular conditions in Nebraska. Our combination of wind and sunshine are unusually destructive to paint. Studies of special protective coatings for structures exposed to weather might be appropriate.

In the reclamation field we must move toward better development of wells for irrigation and general water supply. A study of all methods of

land preparation for irrigation would be appropriate for any school located in the upper reaches of the Missouri River Basin. Ingenious erosion control structures have not yet all been conceived.

Rural electrification is still in the expanding period in our region. The possibilities of greater use of this power have scarcely been touched.

We in Nebraska believe that small communities have special social values and that it would be a national calamity if they were lost. They can best be preserved by making it possible to have conveniences more readily available to the citizens outside the larger towns and cities and thereby make living more interesting and pleasant.

This is not an exhaustive listing of potential possibilities but they illustrate the fact that a combined engineering attack should be made upon them. The Agricultural Engineer, if he is to develop himself and his opportunities, must join with all men of science and engineering in serving his region.

It should be plain that the place of Engineering Experiment Stations in Agricultural Engineering extends throughout the whole pattern of development of the profession including the responsibility to expand and improve knowledge, the sharing of knowledge so that all may benefit and finally in creating the condition where engineering may deserve a position of high esteem among all men.

A Curriculum for Metallurgical Engineering*

By J. P. SPIELMAN

Professor of Metallurgy, Montana School of Mines

It is a genuine pleasure to be in attendance for the first time at a national convention of our society. It would also be a pleasure to pose this afternoon as a great educator and student and to promise you a scholarly paper dedicated to the theory of higher education. But I can do none of these things and must plead guilty to being a neophyte in the field of education and guilty to being largely a student of industry and of industrial research. As a result, my presentation of the subject "Curricula for Metallurgical Engineers" must be partly from the standpoint of an outsider and partly from the standpoint of one so new to the great profession of teaching that he does not recognize sacred ground when it is seen.

It is advisable to make clear at the outset that this discussion is concerned with curricula leading to the Bachelor's degree in Metallurgical Engineering; curricula designed primarily to train men to enter the profession directly or to continue their studies in the graduate school.

I wish to make clear that there is no *curriculum* for metallurgical engineering. Like all other engineering problems many acceptable solutions are possible, each accomplishing the desired result. This is because our educational institutions differ widely in equipment and personnel, and still more widely in raw material. The basic problem in all institutions, however, is "What shall we teach and how shall we teach it?" This is not a new problem but the age old one, aggravated by the great social and technological changes of the times. It is the simple plant problem of the best process to convert a given raw material into a given end product, complicated to some degree by the desirability of retaining the individual characteristics of the raw material.

Let us for the moment relegate this problem to the field of engineering, reduce it to its simplest form, solve the component part and then inject into the solution the human element, the individualisms of the raw material and the processor.

The production of any material is predicated on a market, a demand for a material of relatively definite specifications to meet a specific need. This is equally true of our educational processes in certain fields and we are justified in assuming that a demand does exist for metallurgical engineers and that it will continue to exist. The first portion of our problem then is to determine the general specifications of our product. Considering ourselves, the educators, as the processors, it is not for us to say what specifications our product should have but rather for industry, the customer, to specify

* Presented at the 55th Annual Meeting, A.S.E.E., Minneapolis, June 17–21, 1947.

(neglecting momentarily the graduate school). Many articles and surveys have been published on this subject during the past several years and recommendations of our society are an authoritative guide. I wish to make a brief presentation of these specifications, however, from another source because it comes directly from industry independent of any organized survey. The following specifications for the newly graduated metallurgical engineer are taken from several hundred personal communications and interviews with industrial leaders and practicing metallurgical engineers:

1. He must be able to speak and write the English language correctly and with reasonable fluency.
2. He must be thoroughly grounded in the basic sciences and the fundamentals of metallurgy and engineering.
3. He must be inculcated with the engineering approach to a problem and the engineering method of solving it.
4. He must have a knowledge of the functioning and the problems of the society of which he is a part and he must be willing and able to assume more than an average share of the responsibilities of citizenship.
5. He must have a knowledge of the field of human engineering.
6. He must have imagination, initiative, ingenuity and integrity.
7. He should enter industry with some understanding of the economic structure of American business.
8. He must be willing to work for his place in the profession, learning as he does so.

These specifications are general over the nation with no differentiation by geographical location and no differentiation by fields or branches of the industry. It will be noted that in the above requirements there is no mention of the specific ability to *do* certain things. This, I believe, is a most significant fact and is a definite trend throughout industry—a radical change from the years past when we were forced to take much of the students time for the presentation of "bread and butter courses" in order to insure him employment. All of our larger metallurgical enterprises have inaugurated training programs of one type or another. Of the programs of this type which I have examined during the past two years, the shortest covered a period of three months and the longest a period of nearly three years. This is a positive indication that industry prefers to teach the "how" of metallurgy. The only exception to the above seems to be small operators and an examination of their plants reveals that they hire few, if any, new graduates, preferring to hire men with several years of industrial experience.

Another definite and significant conclusion can be drawn from these specifications. Scholastic standing has and always will be an important criteria in the evaluation of a graduate but it is not the sole criteria and in many cases is not considered the most important. Industry holds, and rightfully so, that the graduate with the greatest engineering promise is the man possessing the greatest number of the desired characteristics all to a reasonable degree. In other words, the student who might have had an A but took a B in order to devote time to experimentation in student government, forensics, and music; in order to devote time to the study of current labor legislation and labor relations

and to do library work in allied fields not covered in the classroom. Industry is going much deeper into the qualifications of its potential metallurgical engineers than the veneer which is indicated by a cold scholastic average. It is seeking the man with the solid foundation on which to build a professional career, the man who can earn and hold the respect of his fellow workers and his fellow citizens. Industry no longer looks to the colleges for a supply of technicians but for a supply of educated individuals from which true professional engineers can be developed.

This phase of our problem intrigues me because of my years of industrial training and if time permitted I could speak about it endlessly but I would like to close this discussion of our end product with the words of a dear friend, one of the outstanding metallurgical engineers of the West. While discussing these problems with him some 18 months ago I hastily outlined some of the changes I contemplated in our scholastic program. I must have waxed rather enthusisastic because when I stopped for lack of breath he took advantage of the pause to say, "That sounds very interesting and I am sure will prove successful, but remember, *we in industry make the engineer*, YOU SHAPE THE MAN!"

In the period since this interview my studies of industry's requirements of new graduates have continued and have covered the United States and much of Canada and Mexico. The further I go into the subject the more I am convinced that this statement reduces this phase of our problem to the simplest terms. Not just the shaping of the character of the man but the shaping of his mind—his imagination —his professional ethics—his judgment —his tolerance—and the shaping of the foundation on which industry will erect the structure which is the professional metallurgical engineer. This then is our job.

Before deciding on the processes by which we will shape this product we must first examine our raw material —the individuals entering our colleges and whom we must develop into potential metallurgical engineers. I do not believe that our veteran students pose a special problem. It is unfortunate that at this time of great social and technological changes, with the moral obligations on our educational institutions greater than at any time in history that the physical problems resulting from the veterans return should be of such magnitude that in many cases they mask the basic problems of education. Most of the problems of the veteran student are physical; housing, classroom and laboratory space, equipment, staff, and personal problems aggravated by the age and experiences of the student. Educationally, however, they are the product of our secondary schools and while they will, to some extent, affect the "How to teach" portion of our problem they do not alter the "What to teach." We must also, in long range planning, and I believe all curriculum planning should be long range, consider the veteran class of students as temporary.

We are all familiar with the educational procedures of our secondary schools and although we all feel that they should produce for us a tailor made product we must realize that this is impossible. To briefly restate our problem we must accept as our raw material both young and older students, expecting them to be weaker

in cultural subjects, especially English, broader in their scientific horizons and in their knowledge of world affairs, more independent in their thoughts and actions and in all cases eager for technical training and somewhat resentful of the required cultural and Humanistic-Social training. From this raw material we must shape a man grounded in the sciences, in his responsibilities to society and possessing all the traditional characteristics of an educated person.

There are hundreds of ways to reach this objective anl I would not presume to offer a minutely planned fool-proof solution adaptable to all institutions and all individuals. I wish to present, however, a solution to the problem which I believe embodies all the basic elements in a balanced relation one to another. Time will not permit a detailed discussion of all elements or all the reasons for the solution. This is not necessary for like all problems, when the various elements are seen clearly, the solution is obvious and simple. I propose the following curriculum under six major headings and beg your indulgence in my deviation from the conventional sub-headings.

Group I. Basic Engineering Subjects—15.0% of total required hours.

These should include drawing, descriptive geometry, surveying, topographic drawing, applied mechanics, hydraulics, strength of materials, and electrical engineering.

Group II. English—6.0%.

This should include literature (both technical and classic), composition (written and oral) and technical and business writing. Courses in public speaking have been included eleswhere. These courses should be very carefully planned to make them interesting and definitely should not be a rehash of high school grammar courses. Proper presentation of these courses is a real challenge to our English departments and they must meet it.

Group III. Humanistic-Social Group —15.0%.

This group should be fluid to allow for adjustments to meet the needs of individuals. In general, I like to balance roughly six sub-groups as follows: History—20%; Economics—20%; Political Science—20%; Sociology—20%; Psychology—10%; Public Speaking—10%. I like public speaking included as an integral part of this stem. Where better to study parliamentary procedures than concurrently with political science, or debate than concurrently with economics or sociology or history? I also believe that into this stem should be woven the hours for a foreign language by adjustment of the balance or if necessary or desirable by adding hours to the schedule.

Group IV. Basic Sciences—35.0%.

These should include: Chemistry—45.0% and the courses should cover General Chemistry, Qualitative and Quantitative Analysis, Physical Chemistry, Electro-Chemistry, Organic Chemistry, and Chemical Thermo-dynamics. Physics—25.0% and should include at least one good course in Modern or Advanced Physics to include the theory of radiations, electronics, etc. Mathematics—30.0%; and may I say that there is never too much mathematics in a curriculum for metallurgical engineering.

In connection with the basic sciences I will risk my professional head and express the wish that it were possible to include some hours in the basic science of biology in all engineering

curricula. It does not seem to me that omission of some training in the great science of life is compatible with true education.

Group V. Mining and Geology—6.0%.

These should include Historical Geology, Mineralogy, and a survey of Mining Practice and Mining Law. The courses should be planned to furnish a knowledge of the earth on which we live and to broaden the students knowledge of the general field of the mineral industry.

Group VI. Metallurgy—23.0%.

I should like to dwell for a short time on this portion of the curriculum because it is with the subjects of metallurgy that we are most directly concerned. The first question is "What shall we teach?" and in direct answer to this question I say with all the sincerity I possess, "It does not matter so long as we avoid over-specialization as we would a plague and so long as it is truly WELL TAUGHT!" Oviously, no two people would present the same material even under the same course title and the same course description. Obviously, no two colleges will be identically equipped and staffed. I believe, however, in a more or less general guide on the distribution of time to the various fields of metallurgy. All students should have a good introduction to general metallurgy, metallurgical calculations and metallurgical laboratory procedures. This should be allotted about ⅛ of the total time. Another ⅛ of the time should be allotted for training in the great field of Mineral Dressing and another ⅛ of the time for such courses as Fire Assaying, Thesis, seminar and plant study. The remaining ½ of the total time should be equally divided between extractive and adaptive subjects. The extractive subjects must include all of the processes, hydro-, pyro- and electro-metallurgical. The adaptive courses must include physical metallurgy, metallography, ferrous and non-ferrous alloys and heterogeneous equilibrium. All of these courses must be held to fundamentals in order to economically utilize the students time and to avoid teaching much that will be obsolete by the time the student begins to practice his profession.

A word at this point about fire assaying and the time allotted to it. I maintain that it is not our function to train assayers and furthermore that the determination of gold and silver values is basically just another quantitative chemical determination. I also hold, however, that a well planned and well taught course in fire assaying can and should be a most effective introduction to pyro-metallurgy and that the time devoted to it is justified for this reason and for this reason alone. The effectiveness of the course depends entirely on how and by whom the course is taught—a competent metallurgist or an assayer. My own recent experience has proved the value of a proper course in fire assaying beyond the shadow of a doubt.

In teaching the processes I believe that we must constantly remind ourselves of industry's part in the development of the engineer. Let us leave to them the portion of the training which is rightfully theirs. Fifty years ago the problem of presenting the processes was a relatively simple one. The number of industrial metals were few and they were studied one at a time with all the details of their respective processes. Today, with our almost endless list of industrial metals

this is impossible and undesirable. Impossible because of lack of time and undesirable because of rapidly changing processes. But the properties of metals and their compounds and the fundamental principles of our basic processes do not change. It seems desirable then to recommend the teaching of extractive metallurgy, or as I prefer to call it "chemical metallurgy," from the standpoint of the unit processes emphasizing the basic scientific principles of each. I frequently liken the metallurgical engineer to a painter, who with a few basic colors selects those he needs, blends them together and produces a new color—so the metallurgical engineer with a few basic processes selects those best suited to the solution of a given problem, combines them and a complete new process or plant results. Many problems should be presented with such a course, first to drive home the application of the principle and second because the metallurgical engineer who cannot calculate has lost the race before the starting gun has been fired.

The subjects in adaptive metallurgy must be sufficiently broad to draw heavily on the students previous training in physics and mathematics. How this is to be accomplished is an individual problem but the student must complete the courses with a thorough understanding of the basic principles of equilibrium, the nature of metals and alloys and some knowledge of modern tools for research in this field, *i.e.*, radiography, diffraction patterns, the electronic microscope, etc.

I believe implicity in the undergraduate thesis. This is a milestone in the student's career, a finalé to his training which he prizes highly. There is, however, ***danger*** in this course. We must exercise the greatest care that we do not try to make the student run before we have taught him to walk. Many students suffer severe frustration over a thesis problem through no fault of their own. Original and independent research is most difficult for the average undergraduate because many subjects basic to his problem are being studied concurrently with the research. I believe that thesis problems should be carefully planned in advance so the student can be led without his realization to a definite and *positive* solution accumulating some negative information along the way. The problem and its solution should be planned to accomplish certain definite things aside from the actual writing of the report. (1) It should fire the student's imagination and create a thirst for new knowledge. In other words it should awaken a true research sipirt. (2) It should teach him to see and record that which has actually occurred and not that which is expected or hoped for. (3) It must teach the value of negative information as well as the value of positive information. (4) It must make him feel that he has contributed something definite to the world's store of knowledge.

During my years of industrial research I had three problems with young engineers bearing on these points. The first was to train them to see and record that which had actually occurred—not the hoped for occurrence. I believe this is the result of too many cut-and-dried experiments where the answer or result is known before the experiment is performed and anticipation masks true observation. I should refer to these as exercises, not experiments. The second problem was

the careful accurate and complete recording of negative information. The old answer. "It didn't work, so why bother," was invariably given. This reflects a lack of professional training, a lack of the true research spirit. They have no thought for the people or the work which is to follow. The third great problem was imagination, or rather a lack of it. Much can be done to develop imagination in a carefully planned thesis, in fact, throughout the entire curriculum and it is here that we must cease to consider our students as raw material and delve into the personal traits of each individual in order to develop to the fullest the rampant imagination present in every youth.

How to do this specifically and how to teach in general are questions I cannot answer. I know, however, that every teacher must, in his own way, do more than teach, he must inspire at all times. Each of us must exemplify in every way and at all times the true American way of life if we are to shape the men our students will become. Research is one way to accomplish this. A sage, long since forgotten, defined teaching as "seeking and transmitting truth." In my simple one track mind I have never been able to separate the search from the transmission or the transmission from the search—they are as inseparable as the gold dust twins. Any curriculum not constantly enriched by research is drab indeed and doomed to failure. Any teacher who does not inspire himself and his students by research is in a rut and the only difference between a rut and a grave is in the depth. Let us not have in our metallurgy departments teachers who die at 28 and are buried some fifty years later.

In connection with teaching I wish to mention two more courses, the *most* important to a successful engineer but not listed in the curriculum. They must, however, be there. These are courses in "Judgment" and "Tolerance." With these subjects mastered the metallurgical engineer will be a classic success, without them he will be a monumental failure. They must be taught in every course, in every classroom and laboratory, and by every teacher. In addition to teaching them we must live them every minute of every day. We all recognize that all the student learns from his teachers is not passed out in the classroom as information, much is in the very atmosphere of the college, and in the personality of the teacher. These things all teach judgment and tolerance, fire imagination, develop consideration for others, gracious living, the enjoyment of life, and instill a real appreciation of a professional career.

Time does not permit a longer discussion of these points and many more must be omitted. I wish to mention briefly only a few more matters. Our curricula must be sufficiently fluid to allow each student some selection of subjects within certain broad fields but in such a way that the balance is maintained. It must also be sufficiently fluid to allow us to accommodate the outstanding student, the man born to research. Of this student I say, "Take him to your breast and nurture him as you would an orchid for in his development lies the great compensation of teaching, and still more important, he is the insurance for the future of our profession and our Country." These men should be destined for the graduate school which is,

of course, the place for specialization and research. I do not propose a discussion of the graduate school except to say that the above curriculum is an excellent preparation.

This curriculum does not present the problem of what to include but rather of what to exclude and to accomplish our objective we must be constantly weighing each course and all the subject matter therein, ruthlessly *eliminating* any material when we discover something else will serve our purpose better. I emphasize "eliminating" because we are all by nature possessed of the weakness to add and never to subtract. We must remember that the only way to add new cordage to a rope of maximum size and length is to remove some of the old.

We all recognize that the world has entered into a new technical era. I believe that the program outlined above will adequately prepare our metallurgical engineers to take their rightful place in this new world. I also believe that the time to begin preparing them for this place is now! It is true that there is a great demand for engineers at the present time and the report of the committee on manpower indicates that our engineering colleges are in a seller's market. But this will not always be true, and whether it is or is not, our job is still to produce the best possible potential metallurgical engineers. We must shape an educated man from which industry will shape a professional engineer.

A Modern Tower of Babel

By J. ANTONIO THOMÉN

Professor, University of Santo Domingo, Dominican Republic

Thousands of years ago, so the story is told, men, in their desire to reach Heaven, conceived the idea and undertook the task of building the Tower of Babel, and, as a punishment for their boldness, Jehova brought confusion among them by changing their language into different ones, so they could not have understanding among themselves, and so they failed in their task. In this story "Heaven" may be construed as *Happiness Through Understanding*.

Many years after that experience men decided that the pursuit of happiness is one of their inalienable rights, but much has been said and little done to attain it through understanding.

It is very unfortunate that men have given up hope or the desire of an universal language as Esperanto was once expected to become. It seems that the adoption of an existing language is impractical because of rivalries among peoples. It is also a pity that Latin was dropped long ago as the language of learned men.

There is no doubt that great progress in the sciences and mathematics was made in the Renaissance because men of different nations communicated their discoveries to others who would develop them, and the unfortunate incident between Newton and Leibnitz in the field of mathematics can be considered as an isolated case caused by Newton's reluctance to publish his early discoveries.

Whatever motives led Newton to keep his discoveries to himself or induced Leonardo da Vinci to write in hieroglyphics, it is interesting to note that Descartes and Newton published the Discours and the Principia through the advice or efforts of others. There seems to have existed a sort of selfishness, pride or uninterested greed in men of science who treasured their discoveries as modern inventors treasure their inventions. It is possible that this attitude still exists in our days, but we must see to it that whatever is published shall not be left to be rediscovered in our time.

There is no doubt that much happiness can be attained through understanding among men. Great benefits can also be obtained. But understanding requires a common language and engineers should have a common language of symbols, definitions, units and conventions.

The American Society for Engineering Education has been very foresighted to invite observers from the Latin American countries to its Annual Convention of this year in Minneapolis. This is an excellent way of seeking understanding among the men of the engineering profession who should have a common language.

Therefore, for the benefits which

will obviously be obtained thereby, it is hereby moved:

That the American Society for Engineering Education Recommend the Adoption of International Normal Symbols for the Different Subjects Treated by Engineers; That it Promote the Publication of Comprehensive Standard Books on the Said Subjects; and That It Start and Follow a Movement for the Use of the Metric System of Units in All the Subjects Treated by Engineers, as It Is Used in Physics, in Electrical Engineering and in Laboratories.

Many motives can be brought forth to add weight to this motion. I shall endeavor to be brief by using a few illustrations.

One motive is exemplified by the mission of Mr. S. S. Steinberg, as explained in the paper presented by him in the 54th Annual Meeting of the S.P.E.E.: the carrying out of this motion is a first step toward the attainment of the purposes of his trip to South America. American books and periodicals will be more widely read by Latin American engineers when so much decipherment become unnecessary and, this being eliminated, a wider interchange of publications, information and knowledge among engineers will result. This will also promote the study of one another's languages, thus making possible the exchange of engineering professors among different universities and countries.

A second motive for the present motion is that it affords the solution to the difficulties encountered in the "Coordination of Teaching in Physics and Engineering Mechanics." In the article and discussions published in the JOURNAL of April 1947 under the title just quoted, the difficulties that the student goes through in passing from the study of Physics to that of Mechanics are mentioned. The experience is well remembered by all those who had to "unlearn" their Physics (as Mr. Schubmehl puts it). On this question Mr. Potter puts his finger in the sore spot when he writes: "In Physics we are afflicted with the necessity (of teaching Metric as well as English system)." The correct statement should have been: "In Mechanics we are afflicted with the use of the English system."

A third motive has its origin in the fact that engineering education is ever tending to be more humanistic and the engineer must therefore have more expedient means for deepening his information by studying the matter of his subjects from different sources, written with the same symbols, sign conventions and units as he studied the elements of the subject while in school, lest he has to "unlearn" that which he already knows, before he can become proficient in any one field.

The chapter on the Slope Deflection Equations which is found in practically all the books on Reinforced Concrete and on the Theory and Design of Structures may be taken as an example to make this point clear. The difference in the presentation by the different authors usually consists in a new convention of signs, a different figure used in the derivation of the equations and various changes in the exposition by means of which the author complies with the usual "This book or any part thereof must not be reproduced. . . ." On the other hand, many important points in the

original sources are left out in the new presentations, as happened, to name an example, in the case of the semi-graphic solution of compound stresses given by Rankine in his Applied Mechanics, a method which is so appropriate for visualizing purposes.

It is hoped that this motion, which to some may appear as an insurmountable mountain, will be received in good heart and that the modern engineers may set the example by building this modern Tower of Babel and thus the Lord, with his blessing, reverse the judgment of the Terrible God of the Ancients.

New Members

ARENDT, J., Instructor in Structural Engineering, Fenn College, Cleveland, Ohio. S. M. Spears, G. H. Smith.

BASSAR, NICHOLAS, Instructor in Civil Engineering, Montana State College, Bozeman, Mont. E. R. Dodge, R. C. De Hart.

BOECK, RALPH E., Associate Professor of Civil Engineering, Marquette University, Milwaukee, Wis. O. N. Olson, R. J. Smith.

BUDDE, FRANCIS J., Assistant Coordinator, Industrial Coordination, University of Detroit, Detroit, Mich. W. P. Godfrey, D. C. Hunt.

BUTTERFIELD, ROBERT E., Associate Dean, Robert College, Istanbul, Turkey. F. L. Bishop, Nell McKenry.

CAMERON, A. E., President, Nova Scotia Technical College, Halifax, N. S. F. L. Bishop, Nell McKenry.

CARR, T. D., Dean of Engineering, University of Kansas, Lawrence, Kan. K. B. McEachoon, M. M. Boring.

CASON, FRANK L., Coordinator of Placement (Assistant Professor), Purdue University, Lafayette, Ind. A. A. Potter, W. A. Knapp.

CHUKWUEMEKA, NWANKWO, Assistant Professor of Mechanical Engineering, Howard University, Washington, D. C. A. E. Richmond, D. E. Howard.

CLEMENT, WILLIAM D., Instructor in Mechanical Engineering, University of New Hampshire, Durham, N. H. O. T. Zimmerman, E. H. Stolworthy.

COBB, R. N., Assistant Professor of Mathematics, Worcester Polytechnic Institute, Worcester, Mass. H. Rice, R. K. Morley.

CROSS, EDWARD F., Assistant Professor of Engineering, Walla Walla College, Walla Walla, Wash. S. J. Tracey, G. P. Rettig.

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EKSE, MARTIN, Instructor in Drawing, University of Wisconsin, Madison, Wis. R. R. Worsencroft, H. D. Orth.

FELGAR, ROBERT P., Instructor in Engineering Mechanics, University of Texas, Austin, Texas. W. R. Woolrich, B. E. Short.

FLITNER, DAVID P., Instructor in Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. N. S. Hibshman, R. E. Lake.

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SKINNER, WILLIAM J., Assistant Professor of Mechanical Engineering, Cornell University, Ithaca, N. Y. L. T. Otto, E. R. Watt.

SQUIER, WILLIAM W., Director of Educational Research, National Air Council, 1602 Edgewood Drive, Royal Oak, Mich. F. L. Wilkinson, C. T. Reid.

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STAPLETON, H. N., Research Professor of Agricultural Engineering, University of Massachusetts, Amherst, Mass. G. A. Marston, M. E. Bates.

SWEARINGEN, LLOYD E., Professor of Chemistry, University of Oklahoma, Norman, Okla. R. V. James, F. G. Tappan.

VACCARO, MICHAEL J., Student Counselor, Guidance Center, John Carroll University, Euclid, Ohio. H. R. Young, R. R. Slaymaker.

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WANER, N. S., Instructor in Heating, Temple University, Philadelphia, Penna. J. A. Goff, G. H. Bush.

YAROCH, WILLIAM L., Instructor in Chemical Engineering, University of Detroit, Detroit, Mich. H. Gudebski, C. N. Duncombe.

89 new members, 10–3–47

Necrology

William Elgin Wickenden

The death of William Elgin Wickenden, fortieth President and eighth Lamme Medalist of the American Society for Engineering Education, brings to an untimely close one of the most brilliant and fruitful careers in the history of engineering education. Dr. Wickenden's death, at his summer home at Jaffrey, New Hampshire, occurred on September 1, 1947, but a few hours after his retirement as President of Case Institute of Technology, a post he had occupied since 1929. He was approaching his sixty-fifth birthday. He is survived by his wife, Marion Lamb Wickenden, his son William C., and his daughter Elizabeth.

Dr. Wickenden was a native of Ohio, and was awarded the baccalaureate degree by Denison University in 1904. He pursued graduate courses at the University of Wisconsin, and served as instructor at that institution from 1905 to 1909. From 1909 to 1918, he served successively as Assistant Professor and Associate Professor of Electrical Engineering at the Massachusetts Institute of Technology. He then transferred to industry, continuing his career in educational work as Personnel Manager of Western Electric Company from 1918 to 1921, and as Assistant Vice President of the American Telephone and Telegraph Company from 1921 to 1923. These positions broadened his educational experience and brought him into contact with many of the men in engineering education with whom he was later to be intimately associated for the rest of his life.

It was during this period that he made a noteworthy address at the Annual Convention of the Society at Cornell University, in 1923. This address, which showed his remarkable powers of analysis, interpretation, and expression, was made at the time when the Board of Investigation and Coordination of the Society was about to launch its great study of engineering education, and confirmed the belief that Dr. Wickenden should become its director. For the next seven years, he rendered distinguished service to engineering education, through the results achieved by the investigation, which have served ever since as a major influence in setting the general pattern of engineering education in this country.

In 1929, upon completion of the investigation, Dr. Wickenden became President of the Case Institute of Technology, where he served until his retirement. But his service to engineering education did not end with the completion of the investigation. He continued to exercise strong influence upon the ideals and standards of the engineering profession at large. He was one of the founding members of Engineers' Council for Professional

Development, a Fellow and Vice President of the American Association for the Advancement of Science, and Vice President and President of the American Institute of Electrical Engineers. A week before his death, he had been appointed as a representative for engineering on the United States Commission of the United Nations Educational, Scientific, and Cultural Organization, perhaps the crowning appointment of his career. He also served as a member of the two recent committees of 1940 and 1944, on the Aims and Scope of Engineering Education and on Engineering Education After the War, and on the committee which framed the recently adopted new Constitution of the Society.

Dr. Wickenden exemplified in his own career many of the ideals he expressed for his profession, including what he termed a sustaining interest and relationship to national and civic cultural activities. His membership in twenty-five societies and organizations was not merely the act of joining them; he rendered active service as counselor, participant, and leader in their affairs. Dr. Wickenden was noted, among other qualities, for his conspicuous ability as a writer and speaker, and for the clarity and fluency of his expressions. This was not a mere matter of superficial fluency; it was based upon the more fundamental qualities of a quick and virile mind, a great fund of information, the ability to analyze clearly and simply, and to grasp quickly the broader aspects and implications of a great variety of problems. What Dr. Wickenden wrote and said was based upon clear thinking, and the lucidity of his remarks upon knowledge transmitted through accurately chosen words. A study of one of his contributions to the literature of engineering education, of which his "Comparative Study of Engineering Education in the United States and in Europe, 1929," is one of the most outstanding, will reveal an astonishing amount of information, arranged in clear and coherent form, and a discerning analysis of a complex and varied situation, all presented in simple tabulations and clear language.

Dr. Wickenden was a man of fineness and strength of character. He possessed an attractive personality, which impressed itself at once upon those he met. His friendships were staunch and lasting, and he was led to the accomplishments of his career by an impelling motive of public service.

Dr. Wickenden's loss is indeed a severe one to education and public affairs in the United States, and especially to engineering education, but the results of his work will continue for many years to constitute the most substantial monument that could be erected to his life and career.

Frederic Lendall Bishop

It was on August 26, 1876, that Frederic Lendall Bishop was born in St. Johnsburg, Vermont. It was on October 11, 1947, that he died in Pittsburgh, Pennsylvania. During this span of busy years he saw the infant Society for the Promotion of Engineering Education grow from a membership of 415 in 1907 (the Society was founded in 1894 with a membership of 156) and mature into the American Society for Engineering Education with a membership of over 5000 in 1947.

Dr. Bishop obtained his first degree at Massachusetts Institute of Technology in 1898 and his Ph.D. in Physics at the University of Chicago in 1905. He became a member of the Faculty of the Physics Department at the University of Pittsburgh in 1909. Dr. Bishop was Dean of the College of Engineering from 1910 to 1927 and was one of the pioneers in introducing the cooperative system into Engineering Education. In 1927, his love of teaching led him to desert academic administration and return to the class room teaching of Physics. He was Head of the Department of Physics at the time of his death. He was a member of many scientific groups including the American Institute of Electrical Engineers, the Engineering Society of Western Pennsylvania and the American Physical Society. The University Club of Pittsburgh and the Cosmos Club of Washington knew him as a genial member.

Dr. Bishop became a member of the Society for the Promotion of Engineering Education in 1907, a member of Council in 1912, and the Secretary of the Society in 1914. It was not by chance that this Society has unique characteristics; it was because of the keen understanding of this man for engineering education and engineering educators that the characteristics of this Society are as they exist. One senses this uniqueness. It is indefinable. It is Frederic Lendall Bishop.

Dr. Bishop was not one to employ the English language to confuse issues. His methods and his language were direct and to the point. His stand on a point at issue was straightforward, and unmistakable. In a word, he was intellectually courageous. To his hosts of friends all over the world he was kind and considerate, thoughtful and humorous, stimulating and generous.

His passing is a distinct shock to his many friends and a tragic loss to the Society where his advice and counsel would be priceless at this stage of development of the Society.

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